ARIZONA GAME AND FISH DEPARTMENT



RESEARCH BRANCH TECHNICAL REPORT #28

SUMMER RESOURCE SELECTION
AND YEARLONG SURVIVAL OF
MALE MERRIAM'S TURKEYS IN
NORTH-CENTRAL ARIZONA,
WITH ASSOCIATED IMPLICATIONS
FROM DEMOGRAPHIC MODELING
A Final Report

BRIAN F. WAKELING TIMOTHY D. ROGERS September 1998

FEDERAL AID IN WILDLIFE RESTORATION PROJECT

Arizona Game and Fish Department Mission

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft and off-highway vehicle recreation for the enjoyment, appreciation, and use by present and future generations.

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Brian F. Wakeling Timothy D. Rogers

September 1998

Federal Aid in Wildlife Restoration Project W-78-R

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CONTENTS

Abstr		•••
Introc	uction	
Study	Areas	
	Chevelon Study Area	
	Mormon Lake Study Area	
Metho	ods	
	Capture and Telemetry	
	Habitat Selection	
	Dietary Selection	
	Summer Use Areas	
	Survival Analysis	
	Population Modeling	
	Relative Population Status	
Resul	[[[[[[[[[] [[[] [[] [[] [[] [[] [[] [[]	
	Capture and Telemetry	1
	Habitat Selection	1
	Dietary Selection	14
	Summer Use Areas	15
	Survival	
	Population Modeling	16
	Relative Population Status	
Discu	${\sf SSION}$	
	Habitat Selection	
	Dietary Selection	
	Capture and Summer Use Areas	
	Survival	
	Population Modeling	28
	Relative Population Status	29
Mono	gement Implications	2 1
viana		
	Habitat	20
	Populations	32
Litera	ture Cited	34
Annei	ndixes	41
rhhei	MIACO Selection of the contract of the c	



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SUMMER RESOURCE SELECTION AND YEARLONG SURVIVAL OF MALE MERRIAM'S TURKEYS IN NORTH-CENTRAL ARIZONA, WITH ASSOCIATED IMPLICATIONS FROM DEMOGRAPHIC MODELING

Brian F. Wakeling and Timothy D. Rogers

Abstract: We studied male Merriam's turkeys (Meleagris gallopavo merriami) in north-central Arizona because their summer habitat use and yearlong survival was suspected to differ from that documented for female turkeys. Our ability to predict how resource management activities would influence male turkeys was limited to inferences drawn from studies on female turkeys. We radio marked 7 (6 adult, 1 subadult) male turkeys on the Chevelon study area and 58 (40 adult, 18 subadult) male turkeys on the Mormon Lake study area. We measured habitat attributes on 18 loafing sites, 30 roosting sites, and 48 feedings sites used by male turkeys during summer and 96 corresponding random plots. Male turkeys showed little third-order selection for feeding sites or food items, but strong fourth-order selection for forbs in the diet. Persistent mast items and insects were also selected in the summer diet. Male turkeys used large (>50 cm) diameter ponderosa pine (Pinus ponderosa) trees for roosting in high basal area (21.2 m²/ha) stands, typically located on steep (>30%) slopes. Greater short cover (<46 cm tall) from conifer trees, greater ponderosa pine basal area, and greater slope were the best predictors of roosting habitat. Male turkeys selected loafing habitat with greater amounts of downed wood, smaller (15 cm) mean diameter ponderosa pine trees, and more tall cover (92-184 cm tall) from conifer trees than at random plots. Greater tall (92-184 cm) conifer tree cover and shorter (<4 cm) herbaceous plants were the best predictors of loafing habitat selection. Unlike females, radio-marked male turkeys were not harvested during the fall turkey hunt. Male mortality due to spring hunting (0.274) was greater than female mortality due to fall hunting (0.026). Harvest rates on adult and yearling males did not suggest current overexploitation. Based on stochastic population modeling and Monte Carlo simulations, adult female turkey survival has the largest potential to affect turkey population levels. Improved adult female turkey survival has a greater effect than nesting by yearling female turkeys, but yearling female nesting was the demographic parameter with the greatest potential for improvement. Even moderate levels of improvement in yearling nesting rates results in marked increases in simulated turkey populations. To effect population increases, efforts to improve the nutrition of yearling female turkeys, and hence their propensity to nest, are likely to be more effective than predator control to improve turkey survival.

Key Words: demographics, diet, feeding, habitat selection, habitat use, loafing, Merriam's turkey, Meleagris gallopavo merriami, population modeling, roosting, survival

INTRODUCTION

Survey data (Green 1990) and the perception that turkey populations had declined throughout the Southwest (Shaw 1986) prompted research into Arizona's turkey populations. Various land use practices such as timber harvesting, ungulate grazing, recreation, and fuel-wood cutting were implicated as causes for the decline (Shaw 1986). These factors can influence habitat suitability and resource availability necessary to support turkey populations.

In Arizona, turkey resource selection varies by season, behavior, and gender. Turkeys select an array of forest stand characteristics, tree densities, and seral stages to attain these resources (Wakeling 1991, 1997; Stone 1993; Wakeling and Shaw 1994; Mollohan et al. 1995; Wakeling and Rogers 1995a, b, 1996; Wakeling et al. 1997a, 1998).

For instance, females with young feed within small (<1 ha) herbaceous openings that provide many forbs, grasses, and invertebrates, whereas they loaf within stands of dense intermediate timber (25-35 cm diameter breast height [DBH]). Availability of mast drives feeding habitat selection for both genders during winter, when turkeys seek out Gambel oak (Quercus gambelii) and juniper (Juniperus spp.) concentrations. Shaw (1973) indicated that there was a lack of information concerning summer habitat use by male turkeys, and he suspected male turkeys used different habitats during summer than did females. If male turkey habitat use differs substantially from female use, land management practices may not affect male habitat selection similar to the way it affects female selection.

Many demographic parameters influence turkey populations (Wakeling 1991, Roberts et al. 1995, Roberts and Porter 1996). Turkey populations fluctuate substantially among years, as do nesting rates, nesting success, and agespecific survival rates for females (Wakeling 1991, Mollohan et al. 1995). Male turkey survival has been measured for different turkey subspecies in other habitats and may vary from 0.4 to 0.8 annually (Lint et al. 1996, Paisley et al. 1996, Vangilder 1996). Overexploitation may result in a shift of the age structure of male turkeys harvested in the spring hunting period, with the yearling segment receiving greater representation over time (Kurzejeski and Vangilder 1992). Yet, we know little concerning yearlong survival and effects of predation and hunting on male Merriam's turkeys in the Southwest.

Our study had multiple objectives. Our first objective was to document male turkey resource selection during summer. We employed a hierarchical comparison of diet, habitat use, and resource availability, corresponding with thirdand fourth-order selection (Johnson 1980). Johnson (1980) defined first-order selection to correspond with selection of the physical or geographical range, second-order selection relates to the home range of an individual or social group, third-order selection pertains to use of habitat components within the home range, and fourth-order selection involves procurement of some habitat component at a use site, such as food from a feeding site. We focused on comparisons of habitat characteristics and food availability between use sites and random plots (third-order selection) and diet and food availability at feeding sites (fourth-order selection). Our second objective was to determine annual and seasonal survival and mortality rates for male turkeys. Our final objective was to model the effects of observed and published demographic variation on turkey population growth and stability. Specifically, our objectives were to:

- Identify selected habitat characteristics used by male turkeys during summer;
- Identify selected food items consumed by male turkeys during summer;
- Identify yearlong and seasonal survival rates for male turkeys; and
- Evaluate the influence of various demographic parameters on population trends.

STUDY AREAS

Chevelon Study Area

The 860-km² Chevelon study area (CSA) was located on the Mogollon Rim, approximately 65 km south of Winslow, Arizona, on the Apache-Sitgreaves National Forests in the southern portion of Game Management Unit (GMU) 4A (Fig. 1). Elevations ranged from 1,700 m in the northern portion to 2,430 m in the southern portion. Annual precipitation averaged 47.2 cm, with 2 concentrations, the first during winter storms in January through March, and the second during summer storms in July through early September (Natl. Oceanic and Atmos. Adm. 1991).

Five cover types were present on the CSA based on U.S. Forest Service Terrestrial Ecosystem Surveys (Laing et al. 1989): (1) mixed-conifer (20.1% of area), (2) ponderosa pine-Gambel oak (34.9%), (3) pinyon (Pinus edulis)-juniper (44.4%), (4) aspen (Populus tremuloides) (0.4%), and (5) meadow (0.2%). Mixed-conifer was dominant above 2,340 m and extended downward along east-facing slopes and drainages. This habitat included Douglas-fir (Pseudotsuga menziesii), white fir (Abies concolor), limber pine (Pinus flexilis), and Rocky Mountain maple (Acer glabrum). Ponderosa pine dominated west-facing slopes between 2,340 and 1,850 m. At elevations below 2,150 m, pinyon and alligator juniper (Juniperus deppeana) densities increased. Below 1,850 m, the pinyon-juniper cover type was dominant, with ponderosa pine present along drainages. Gambel oak occurred as a widespread codominant with ponderosa pine and in pockets in the mixedconifer and pinyon-juniper associations.

Timber harvesting and livestock grazing were major land uses on CSA. Logging began in the late 1930s, and initial harvests were group or individual tree selections. Even-aged management was prevalent in the 1980s, but has been limited since 1990. Within individual stands, timber harvests occurred every 20 years, although some stands received additional silvicultural treatment within 5 years of previous harvest. Most ponderosa pine stands on level terrain had been logged at least once; little logging has occurred on steeper slopes in larger canyons. Cutting of fuel wood, particularly in the pinyon-juniper cover type, increased over the past 2 decades. Until the 1960s, sheep were the primary livestock on CSA. The predominant

livestock use on CSA since that time was by cattle during summer. The area received 546,000 recreational visitor days. Road density averaged 7 km/km².

Mormon Lake Study Area

The 3,476-km² Mormon Lake study area (MLSA) comprised portions of GMUs 6A and 5B within the Coconino National Forest (Fig. 1). Elevations ranged from 1,829 m in the southern portion to areas >2,440 m in the northern portion. Precipitation averaged 47.0 cm; winter snowstorms and summer monsoonal rains provided the majority of moisture (Natl. Oceanic. and Atmos. Adm. 1997).

Six vegetation communities occurred on MLSA (Brown et al. 1979): (1) petran montane conifer forest (45.4% of area), (2) great basin conifer woodland (29.0%), (3) interior chaparral (6.5%), (4) semidesert grassland (9.7%), (5) great basin grassland (4.6%), and (6) Arizona upland sonoran desert scrub (4.8%). Mixed-conifer species, including Englemann spruce (*Picea engelmanni*), white fir, Douglas-fir, and ponderosa pine, generally occurred at elevations >2,400 m. Ponderosa pine occurred down to

elevations of 2,000 m. Gambel oak was present in most vegetation communities, but usually occurred as a widespread codominant with ponderosa pine. Pinyon and various juniper species mainly occurred below 2,000 m. Aspen occurred in mountain meadows and mesic draws above 2,200 m. Cottonwood (*Populus fremontii*) and willow (*Salix* spp.) occurred in riparian areas below 2,000 m. Rocky Mountain maple, Arizona walnut (*Juglans major*), and Arizona sycamore (*Platanus wrightii*) occurred infrequently.

Land uses on MLSA included timber harvesting, livestock grazing, fuel-wood cutting, and recreation. Timber removal began prior to 1900, using many forms of transportation, including horse-drawn contrivances, railroads, and trucks. Many forest stands within MLSA were treated experimentally during Beaver Creek Watershed studies. Most other stands received silvicultural treatment similar to that described for CSA. Cattle were the predominant livestock on MLSA. Recreational visitor days within this area approach 1,500,000 annually, although road density was 4.4 km/km², about 63% of CSA density.

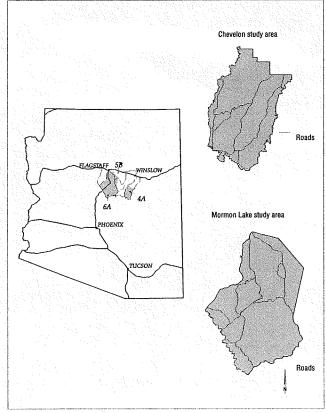


Figure 1. Location of the Chevelon and Mormon Lake study areas in north-central Arizona.



METHODS

Capture and Telemetry

We captured turkeys from December 1 to March 31 during the winters of 1994-95 through 1996-97 with rocket nets (Bailey et al. 1980) at sites we baited with whole oats. We weighed each turkey to 0.1 kg using field scales and classified birds as subadults (<1 year old) or adults (>1 year old) according to wing molt (Knoder 1959, Williams 1961). We tested for differences in weight by age and study area using analysis of variance (ANOVA; SAS Inst., Inc. 1985) and Tukey's mean separation procedure (Zar 1984). Each male turkey was fitted with a backpack-mounted motion-sensing radio telemetry unit (Telonics model LB 400, Mesa, Ariz.) secured with 5-mm bungee harness. We monitored turkeys ≥1X weekly throughout summers (May 15 through September 15), generally from the ground. We also monitored turkeys at least monthly using aerial telemetry throughout the rest of the year. We aerially monitored radio-marked turkeys twice a month during hunting seasons. Turkeys were hunted during a bearded-turkey-only spring season (beginning last Friday in April and running 24 days) and an either-gender fall season (beginning Friday following the first Saturday in October and running for 7 days).

Habitat Selection

During summers of 1996-97, we collected habitat use data from radio-marked turkeys between May 15 and September 15. We obtained approximately 2 radio locations daily. No individual was relocated at the same type of site within a given day to reduce autocorrelation. Behavior at use sites was classified as either feeding, loafing, or roosting. We visually located and observed radio-marked turkeys or feeding sign (e.g., scratching and droppings) from radiomarked or unmarked turkeys to determine the activity center. An activity center was defined as the geographic midpoint of flock or sign when first observed, and Universal Transverse Mercator (UTM) coordinates were recorded using topographic mapping. We measured habitat characteristics within 5 days after birds had abandoned use sites.

We used the activity center as plot center in habitat mensuration. We used a 40-m² circular plot to count shrubs and estimate stem density. A 400-m² circular plot was used to estimate stem density by counting conifer and Gambel oak seedlings (<2.5 cm DBH) and trees (≥2.5 cm DBH). We measured DBH of conifer and

Gambel oak trees on 400-m² plots with a diameter tape. The diameter at root crown (DRC) was measured on juniper and pinyon trees. Mean DBH, DRC, and density data were used to calculate basal area (BA) on plots by tree species according to the formula:

$$BA = \sum ((DBH/2)^2 \times 3.14 \times density) \times 25.$$

DRC was substituted for DBH in the calculation of BA for juniper and pinyon trees.

Ground cover of canopies provided by forbs, grasses, shrubs, deciduous trees, conifer trees, and rocks was measured along 4 7.7-m line-intercept transects (Canfield 1941) at use sites. The first transect was oriented randomly, radiating from plot site center. The 3 remaining transects were oriented 90° from the preceding transect. We measured canopy cover in 3 height categories: (1) 0-45.9, (2) 46-91.9, and (3) 92-184 cm above ground. We estimated overhead crown completeness (Vales and Bunnel 1988) with a spherical densiometer (Strickler 1959) at 4 points 11.4 m from site center, along the same bearings as line-intercept transects. We averaged the 4 values to calculate a mean crown completeness for each site.

We collected data on proximity of openings and horizontal cover at use sites. We ocularly estimated distance (±1 m) to the nearest canopy opening, if present within 200 m, from each site center. We defined canopy opening as any horizontal gap >9 m² in the overstory canopy. We also ocularly estimated dimensions (±3 m) and calculated area of canopy openings. At site center, we noted presence or absence of overhead canopy cover. We estimated height (±1 m) to the bottom of the first canopy. After locating the nearest cover that would obscure a flock of 2-3 turkeys, we ocularly estimated distance (± 1 m) to that cover. We measured horizontal sight distances (HSD) with 2 methods. First, we used a life-size turkey silhouette, placed at site center, and paced away from it along the same bearings on which line-intercept transects were run. This provided 4 estimates of turkey HSD, which we averaged to provide a mean value for each site. Second, we paced away from site center along the same bearings until the person pacing was entirely obscured from a person kneeling at site center. Again, these 4 estimates of person HSD were averaged to provide a mean value.

We classified topographic and silvicultural characteristics at each site. Land form was classified as either a narrow canyon (≤100 m wide at top), wide canyon (>100 m wide), narrow ridge (≤100 m wide), wide ridge (>100 m wide).

or hill side. Use sites were also classified as being on the upper, mid, or lower third of the overall slope. We measured slope with a clinometer, and classified aspect as north-facing (316-45°), east-facing (46-135°), south-facing (136-225°), or west-facing (226-315°). Canopy structure of the forest stand was classified as single, 2, or multi-storied. We classified the timing since last silvicultural treatment as untreated, treated >20 years ago, or treated ≤20 years ago.

At turkey use sites, we collected data to index typical human use. We recorded the presence or absence of a barren campsite core, campfire ring, or any trash from human activity. We also noted if a human-induced trail or road existed within 100 m of use-site centers.

For each use site we measured, we located a random plot for comparison. We measured the same habitat characteristics at random plots that we measured at use sites. We located random plots by pacing a random distance (<500 m) on a random bearing from each use site. The random plot was measured immediately after mensuration of each use site.

We tested for differences between study areas prior to comparing use sites with random plots. For continuous data, we analyzed differential use of habitat variables using a distribution-free multiresponse permutation procedure (MRPP; Mielke 1984). Non-continuous data were tested using Chi-square contingency tables (Zar 1984), because availability was estimated from random plots and goodness-of-fit tests were inappropriate (Thomas and Taylor 1990).

We compared habitat in each type of use site (i.e., feeding, roosting, loafing) with corresponding random plots (third-order habitat selection). For continuous data, we analyzed differential use of habitat variables using MRPP. Non-continuous data were tested using Chi-square contingency tables. Differences among classifications in categorical data were determined using Bonferroni confidence intervals (Neu et al. 1974, Byers et al. 1984) and Jacobs' D selectivity index (Jacobs 1974). We deemed all tests significant at $P \le 0.05$.

We developed logistic regression models (Hosmer and Lemeshow 1989) for each type of use site to differentiate it from random plots. We used forward stepwise logistic regression because this approach determined which habitat variables best predicted habitat use (Harrell 1980). In this analysis, we included only variables that differed from random in univariate analyses previously described. We also included a variable for study area to determine if differences between study

areas influenced habitat selection. This multivariate procedure held experimentwise α constant and simultaneously evaluated categorical and continuous data. We set $P \le 0.05$ for variable entry into the model. Variables were excluded from the logistic equation if they correlated ($r \ge 0.6$) with other variables in the equation; in these instances, the variable that explained the least variation was excluded. Classification of use sites and random plots was assigned using 0.5 as the cutpoint.

Dietary Selection

We collected data on food availability and diet of male turkeys during summers of 1996 and 1997 in both study areas. To determine food availability at feeding sites and associated random plots, we collected potential food items in 3 0.35m² circular plots: the first located at site centers, and the 2 remaining plots located 6.2 m from site centers directly opposite each other along the initial line-intercept transect used for habitat measurement. Samples were placed in paper bags in the field and subsequently dried at 50 C for 48 hrs in a forced-air oven. Food items were later identified to the lowest identifiable taxonomic level (e.g., grass, forb, ponderosa pine seed) and weighed to the nearest 0.01 gm. Percent composition of food items at feeding sites was determined by dividing biomass of an individual item by the sum of biomasses of all food items combined.

To determine turkey diet, we used microhistological analyses. We collected fecal samples at feeding sites and pooled fecal samples by year and study area. Plant reference material for voucher specimens and fecal samples were processed according to Davitt and Nelson (1980). Several important modifications were employed in this procedure when compared with other chemical epidermal preparations (Sparks and Malechek 1968, Hansen et al. 1971, Holechek 1982, Holechek et al. 1982). First, fecal material was gently agitated with water at low speed in a blender for several minutes, rather than grinding in a Wiley mill through a 1-mm mesh screen, which might limit the discernibility of some fragments (Vavra and Holechek 1980, Samuel and Howard 1983). Next, fecal material was washed in cool water over a 200-mesh screen (75micron openings) and stored in 95% ethanol for ≥24 hrs to remove pigments. Ethanol was decanted and the residue bleached for 5 to 10 minutes. The residue was rewashed using the 200-mesh screen and placed in a lactophenol blue staining solution for ≥24 hours. Lastly, excess stain was removed using cool water and

epidermal and cuticle fragments were transferred to a slide, covered with glycerin gel, and sealed with a cover slip.

Botanical composition of the pooled diets from fecal samples was determined using a modification of existing relative frequencydensity conversion (Sparks and Malechek 1968, Holechek and Vavra 1981, Johnson 1982) and frequency addition (Holechek and Gross 1982) sampling procedures. A minimum of 25 randomly located fields were sampled on each of 8 slides (200 total views) with identifiable epidermal cell fragments; each slide was considered a replicate. A 10 × 10 square grid (100 total, each 100 micron × 100 micron in size) was mounted in the ocular of the microscope to measure the area covered by each identified fragment observed at 100× magnification and recorded by species. Discernible, but unidentifiable, fragments were recorded by forage class. Percent diet composition was calculated by dividing the percent cover of each plant species by the total cover of all species composing >1%

Because mast comprised <70% of the overall diet, we corrected for differential digestibility (Rumble and Anderson 1993a). We fed formulated diets, containing items identified from natural diets in our study, to penned domestic turkeys (1 broad-breasted white female and 1 bourbon red female) to develop correction factors for diets collected from free-ranging turkeys. We collected fecal samples from penned turkeys after these birds had been on the formulated diet for >2 days. We processed these fecal samples as described for those collected from free-ranging wild turkeys.

We determined relative correction factors to adjust the estimated diet of free-ranging wild turkeys for differential digestibility and fragmentation using a modification of Dearden et al. (1975). We determined cover-based correction factors for each plant category in the formulated diet to account for differential epidermal digestion and discernibility (Milchunas et al. 1978, Gill et al. 1983). We determined correction factors using the equation:

$$DC_{i} = \frac{D_{ik}}{D_{is}}$$

where DC_i was the digestion coefficient of species i, D_{ik} was the percent species i in the formulated diet mixture, and D_{is} was the percent species i from the microhistological analysis of the fecal samples from domestic turkeys fed the

formulated diet. The diet estimated from microhistological analyses of the fecal samples from free-ranging wild turkeys was corrected using the equation:

$$D_{ic} = \frac{DC_i \times D_{if}}{\sum (DC_i \times D_{if})}$$

where D_{ic} was the percent species i in the corrected diet, DC_i was the digestion coefficient of species i, and D_{if} was the percent of species i in the uncorrected diet.

We assessed dietary selection using only items that comprised >1% of the diet because rare species tend to be highly variable and may yield spurious results (Uresk 1990). Differences in composition of food items between feeding sites and random plots were deemed to correspond with third-order selection. Differences between dietary composition based on microhistological fecal analysis and feeding site composition were then considered representative of fourth-order selection. We compared diets between years within study areas using the Mann-Whitney *U*-test (Zar 1984). Comparisons of availability at feeding sites and random plots between study areas were also made with Mann-Whitney Utests. Appropriate pooled comparisons of dietary selection were evaluated using the Kruskal-Wallis nonparametric ANOVA (Zar 1984) to determine if differences existed among diet, feeding site, and random plot composition. A median separation procedure (Miller 1966:166) was used to detect individual class differences. For dietary items that differed among groups, Jacobs' D selectivity index (Jacobs 1974) was applied to median compositional values to determine degree of selection and avoidance in both third- and fourth-order comparisons. All differences were deemed significant at $P \le 0.05$.

Summer Use Areas

We plotted locations of radio-marked male turkeys on U.S. Geological Survey 7.5' topographic maps and recorded the UTM coordinates at summer locations. We entered these coordinates into a Geographic Information Systems (GIS) data base. We used this GIS data base to plot minimum convex polygons (Hayne 1949) surrounding summer use areas for each male turkey that we had >5 summer use locations. We calculated size of each minimum convex polygon use area and compared size of use areas for turkeys between the 2 study areas with 2-sample *t*-tests (Zar 1984).

Survival Analysis

We obtained signals from radio-marked turkeys ≥1X weekly during ground and aerial surveys. We used aerial telemetry to locate turkeys whose signal we had not heard within 3 weeks. When pulse frequency indicated that the transmitter had been motionless, we investigated cause of inactivity. Where possible, we classified mortalities by cause of death: predation, hunter harvest, or other. We calculated causespecific mortality rates using MICROMORT (Heisey and Fuller 1985). We evaluated survival rates by monthly time intervals and combined months with survival rates that did not differ ($P \le$ 0.05) with a Z-test (Heisey and Fuller 1985). We compared survival rates between adult and yearling males within each study area and between age classes by study area with Z-tests. Cause-specific mortality rates were also compared with a Z-test (Heisey and Fuller 1985).

Population Modeling

Sensitivity Analysis. We modified a population model described by Wakeling (1991) to compare effects of demographic parameters we measured and those from literature on turkey population trends. We used the model:

$$N=A+Y+J$$

where N is the August population estimate, A is number of adults in the population, Y is number of yearlings, and J is number of juveniles (poults) in the population. To model adult numbers, we used the equation:

$$A = (A_{-1} \times S_A) + (Y_{-1} \times S_Y)$$

where A is number of adults in this year's population, A_{-1} is number of adults in last year's population, S_A is last year's adult survival, Y_{-1} is number of yearlings in last year's population, and S_Y is last year's yearling survival. To model yearling numbers, we used the equation:

$$Y=J_{-1}\times S_J$$

where Y is number of yearlings in this year's population, J_1 is number of juveniles in last years population, and S_J is survival of last year's juveniles. To model juvenile numbers, we used the equation:

$$J = (E_{\Delta} \times A_{-1} \times N_{RA} \times N_{SA} \times S_{J} \times S_{P}) + (E_{Y} \times Y_{-1} \times N_{RY} \times N_{SY} \times S_{J} \times S_{P})$$

where J is number of juveniles in the population, E_A is number of eggs laid by adults, N_{RA} is nesting rate of adults (proportion of adult females that nest), N_{SA} is nest success rate of adults (proportion of nesting adult females that hatch ≥ 1 egg), S_J is survival of juveniles from August of 1 year until August of the next, S_P is survival of young from hatching to August, E_Y is number of eggs laid by yearlings, N_{RY} is nesting rate of yearlings (proportion of yearling females that nest), and N_{SY} is nest success rate of yearlings (proportion of nesting yearling females that hatch ≥ 1 egg).

Based on demographic parameters measured on CSA, we modeled population trends using the aforementioned deterministic model. We based the model on mean demographic parameters measured in previous studies (Wakeling 1991, Mollohan et al. 1995). We compared an arbitrary initial population estimate (500 adult female, 150 yearling female, 300 juvenile female, assuming sufficient males were available for breeding) with a population estimate from the model 10 years later. We then independently increased each demographic parameter by 10% while holding all others at their initial levels and deterministically modeled the effect on the turkey population 10 years later.

For this model, we used data from studies on CSA. For each variable within the equation, we assumed:

$$E_A$$
 and $E_Y = 4.5$
 $N_{RA} = 0.7$
 $N_{SA} = 0.9$
 $N_{RY} = 0$
 $S_P = 0.35$
 $S_J = 0.49$
 $S_Y = 0.7$

 $S_A = 0.66$

Stochastic Modeling. We modified our model to allow stochasticity. We allowed the demographic parameters to vary randomly within ranges observed during previous studies conducted on CSA. These ranges were not always normally distributed, and random behavior within measured ranges seems to reflect natural variation observed in wild turkey populations (Vangilder 1992). We used 500 Monte Carlo

simulations to detect the frequency with which the modeled population 10 years following initiation declined >20%, declined \leq 20%, increased \leq 20%, or increased >20%. The model was allowed to vary:

$$N_{RA} = 0.35-0.65$$

 $N_{SA} = 0.6-0.9$
 $S_{P} = 0.2-0.6$
 $S_{J} = 0.35-0.85$
 $S_{Y} = 0.52-0.87$
 $S_{A} = 0.5-0.85$

We then used 500 Monte Carlo simulations to model population numbers by allowing demographic parameters to vary within the range observed in studies of Merriam's turkeys from a productive non-native habitat within the Black Hills, South Dakota (Rumble 1990, Rumble and Hodorff 1993). We modeled nesting parameters from this area because they differed substantially from those observed on CSA. The modified parameters for this model varied between:

$$N_{RA} = 0.55-0.8$$

 $N_{SA} = 0.6-0.9$
 $N_{RY} = 0.35-0.6$
 $N_{SY} = 0.6-0.9$

We modeled 2 additional hypothetical situations using 500 Monte Carlo simulations each. The first modification to the stochastic model was to allow yearling females to nest at rates equal to adults on CSA and vary within the same range. This modification was used to simulate the effect on the CSA population if yearling females in the Southwest nested during their first spring. For this model, we modified parameters from our original stochastic model. Those parameters varied:

$$N_{RY} = 0.35 - 0.65$$

 $N_{SY} = 0.6 - 0.9$

The second modification altered the stochastic model by allowing yearling and adult

female survival to improve by 0.2. This modification was used to simulate the possible non-compensatory effect the population might realize if predation was reduced. To model this possibility, we again modified parameters from our original stochastic model. These parameters varied:

$$S_{Y} = 0.7-1.0$$

 $S_{A} = 0.7-1.0$

Ultimately, the assumptions of our stochastic models were:

- 1. Demographic parameters are not influenced by population size (i.e., no density-dependent survival or reproduction).
- 2. Demographic parameters vary independently and randomly (i.e., no correlations exist among demographic parameters).
- Age-specific differences exist among survival and nesting rates, but not for nest success or clutch size.

Relative Population Status

We evaluated the relative population status of study areas annually by conducting summer roadside surveys (Shaw 1973). Five 24-km routes were surveyed by vehicle in each study area (Appendixes 1 and 2). We began surveys at sunrise (about 0600 hrs MST), surveying the route in both directions at speeds ≤24 km/hr. Vehicles contained 1 person who served as observer-driver. These routes received sufficiently light vehicular traffic so that most of the observer's time could be devoted to observation. Routes were surveyed once daily for 4 consecutive days. For each year, we calculated number of turkeys observed per study area using these routes. Because we had only 3 data points per area, we did not statistically compare number of turkeys observed annually between 2 study areas.



RESULTS

Capture and Telemetry

We captured and radio marked 7 male turkeys on CSA (6 adult, 1 subadult) and 58 male turkeys on MLSA (40 adult, 18 subadult). Adult male turkeys did not differ in body weight between CSA and MLSA, but adults were consistently heavier than subadults across both study areas (F = 91.942, 64 df, P < 0.001; Table 1).

Habitat Selection

We located 96 use sites (51 on CSA, 45 on MLSA) during summers of 1996 and 1997. Most locations were obtained late in the day; 18.1% before 1000 hrs, 26.9% between 1000 and 1400 hrs, and 53.1% after 1400 hrs. On CSA, we collected habitat use data on 6 male turkeys, and number of relocations per bird ranged from 1 to 18. On MLSA, we collected habitat use data on 18 male turkeys, and number of relocations per bird ranged from 1 to 6.

Comparisons Between Study Areas. Study areas differed in several forest stand characteristics. MLSA had Gambel oak with greater mean DBH (P < 0.001), greater BA (P < 0.001), tree stem density (P < 0.001), and seedling stem density (P < 0.001) than did CSA (Appendix 3). MLSA also had greater juniper BA (P = 0.022) than did CSA. CSA had more shrubs per ha (P < 0.001) and conifer seedlings per ha (P = 0.008) than MLSA, but MLSA had greater overall BA (P = 0.020) than did CSA (Appendix 3).

Study areas differed in some ground cover categories. CSA had greater ground cover from downed wood (P=0.002) than did MLSA (Appendix 4). But, MLSA had greater cover from all 3 height classes of deciduous vegetation (P<0.001, P<0.001, P=0.030, respectively) than did CSA. MLSA had greater ground cover (P<0.001) from shrubs than did CSA. We detected no differences between study areas in total cover within the 3 height categories (Appendix 4).

The 2 study areas differed in some other site variables as well. Canopy completeness was greater (P = 0.007) on MLSA than on CSA (Appendix 5). CSA had larger openings (P = 0.039) than did MLSA. MLSA had greater height to first canopy (P = 0.017) and herbaceous height (P = 0.046) than did CSA (Appendix 5).

Table 1. Mean weights (kg) (standard deviations) of male Merriam's turkeys captured on the Chevelon (CSA) and Mormon Lake (MLSA) study areas during the winters of 1995-97.

All subadult males $n = 19$	CSA adult males $n = 6$	MLSA adult males n = 40
6.0 (0.7) ^a	8.4 (0.7) ^b	8.0 (0.5) ^b

^{ab}Mean weights with the same letter do not differ (P > 0.05) using Tukey's mean separation procedure.

We pooled availability data between study areas because the analysis of third-order selection for each type of use site did not reveal driving selection for any of the habitat components that differed between study areas, particularly with logistic regression. Pooling increased our sample sizes and the power of our tests.

Feeding Sites. We measured 48 feeding sites (31 on CSA, 17 on MLSA) and 48 random plots during summer 1996 and 1997. Four feeding sites on MLSA were from unmarked male turkeys. We found little evidence of third-order selection with respect to feeding sites. Feeding sites had fewer Gambel oak trees per ha than did random plots (P = 0.040; Appendix 3). Rocks made up less of the ground cover at feeding sites than at random plots (P = 0.002; Appendix 4). Turkeys selected feeding sites in association with a human-induced trail or road more frequently than would be expected at random ($\chi^2 = 6.499$, 1 df, P = 0.011; Table 2). No logistic regression equation could be developed that described feeding habitat selection.

Roosting Sites. We measured 30 roosting sites (12 on CSA, 18 on MLSA) and 30 random plots during summers of 1996 and 1997. One roosting site on MLSA was from an unmarked male turkey. Turkeys exhibited a marked third-order selection for roosting sites in that roosting sites differed substantially from random plots. Living ponderosa pine was the predominant (99.2%, n = 127) tree species used for roosting, although 1 roost tree was a ponderosa pine snag. Another roost tree was a Douglas-fir. Trees used for roosting averaged 52.8 (SD = 7.9) cm DBH.

Forest stands on roosting sites differed from those at random plots. Ponderosa pine trees at roosting sites had larger diameter (P = 0.007; Appendix 3) and greater BA (P = 0.022) than did

Table 2. Selection of habitats in association with some form of human-induced trail or road during summer by feeding male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Proximity to trail or road	Use n	Observed proportion		Available n	Bonferroni confidence interval ^a	Selection ^b	Jacobs' D
>100 m	14	0.292	0.516	49	0.145-0.439	• • • • • • • • • • • • • • • • • • •	-0.422
≤100 m	34	0.708	0.484	46	0.561-0.855	+	0.422

^aOverall $\chi^2 = 6.499$, 1 df, P = 0.011.

random plots. These stands had Gambel oaks with greater diameter (P = 0.005), BA (P < 0.001), stem density (P < 0.001), and seedlings (P = 0.006) than did random plots. These stands had greater overall BA (P = 0.028) than did random plots, although they contained fewer conifer seedlings per ha (P = 0.018; Appendix 3).

Forest stand differences between roosting sites and random plots were also reflected in ground cover within the stand. Roosting sites had greater ground cover from conifer trees within the 0-45.9 cm and 46-91.9 cm height categories (P < 0.001 and P = 0.003, respectively; Appendix 4) than did random plots. Roosting sites also had more ground cover from deciduous trees in the 92-184 cm height category (P = 0.006) than did random plots. Roosting sites had more of all ground cover combined between 46-91.9 cm (P = 0.006) and less of all ground cover combined between 92-184 cm (P = 0.012; Appendix 4) than did random plots.

Roosting sites differed from random plots in other site characteristics. Roosting sites occurred on steeper slopes than did random plots (P < 0.001; Appendix 5). Overhead canopy presence at site center was more common ($\chi^2 = 17.739$, 1

df, P < 0.001; Table 3) and canopy completeness was greater (P < 0.001; Appendix 5) at roosting sites than at random plots. The height to first canopy was greater (P = 0.003) and distance to opening was further (P < 0.001) for roosting sites than for random plots.

Influence of silvicultural treatment on roosting site selection was inconsistent. Turkeys use of roosting sites did not change with time elapsed since silvicultural treatment ($\chi^2 = 1.910, 2$ df, P = 0.385; Appendix 6). Yet, turkeys did not roost in single-storied stands ($\chi^2 = 5.970, 2$ df, P = 0.050; Table 4), but used 2 and multi-storied stands in proportions similar to random plots.

Roosting habitat selection was also influenced by land form and the presence of human-induced roads and trails. Roosting sites were located on slopes of wide canyons in greater proportion and on ridge tops in lesser proportions than that which was available on random plots ($\chi^2 = 17.021$, 4 df, P = 0.002; Table 5). They roosted in narrow canyons and hillsides consistent with availability. Roosting sites were selected on the upper third of slopes, while avoiding the lower third ($\chi^2 = 6.724$, 2 df, P = 0.035; Table 6).

Table 3. Selection of stand with canopy closure at site center during summer by roosting male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Closed overhead canopy		Observed proportion		Available n	Bonferroni confidence intervala	Selection ^b	
Absent	4	0.133	0.573	55	-0.006-0.272	·. <u> </u>	-0.795
Present	26	0.867	0.427	41	0.728-1.006	+	0.795

^aOverall $\chi^2 = 17.739$, 1 df, P < 0.001.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

Table 4. Selection of stand canopy structure during summer by roosting male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Canopy structure	Use n	Observed proportion	Available proportion	Available n	Bonferroni confidence interval ^a	Selection ^b	Jacobs' D
Single storied	0	0.000	0.167	16	0.000-0.000	•	-0.999
Two storied	12	0.400	0.375	36	0.186-0.614		
Multi storied	18	0.600	0.458	44	0.386-0.814	-	

^aOverall $\chi^2 = 5.670$, 2 df, P = 0.050.

Turkeys avoided roosting in proximity to humaninduced trails and roads ($\chi^2 = 16.147$, 1 df, P < 0.001; Table 7).

We developed a logistic regression model that correctly classified 80.8% of roosting sites and random plots (Table 8). Roosting sites were best predicted by more ground cover provided by conifer trees 0-45.9 cm tall, greater ponderosa pine BA, and steeper slope.

Loafing Sites. We measured 18 loafing sites (8 on CSA, 10 on MLSA) and 18 random plots. One loafing site on MLSA was from an unmarked male turkey. We found evidence of third-order selection with respect to loafing sites. Ponderosa pine trees at loafing sites had smaller mean diameter (P = 0.046; Appendix 3) than those on random plots. Downed wood provided more ground cover between 0-45.9 cm above ground (P = 0.012; Appendix 4), as did conifer trees between 92-184 cm above ground (P = 0.030).

Loafing sites had more total cover between 92-184 cm above ground than did random plots (P = 0.044; Appendix 4). Herbaceous vegetation at loafing sites was shorter than that at random plots (P < 0.001; Appendix 5). Loafing sites had closed canopies at site center more frequently than did random plots ($\chi^2 = 17.739$, 1 df, P < 0.001; Table 9). Distance to the nearest opening was greater at loafing sites than at random plots (P = 0.001; Appendix 5). HSD values for turkey silhouettes were lower on loafing sites than at random plots (P = 0.004). Slope was greater at loafing sites than at random plots (P = 0.018; Appendix 5).

We developed a logistic regression equation that correctly classified 75.0% of loafing sites and random plots (Table 8). Habitats with more coniferous cover between 92-184 cm in height and short herbaceous cover were associated with loafing site selection.

Table 5. Selection of land forms during summer by roosting male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Land form	Use n	Observed proportion	Available proportion	Available n	Bonferroni confidence intervala	Selection ^b	Jacobs' D
Narrow canyon (≤100 m)	4	0.133	0.052	5	-0.027-0.293	=	
Wide canyon (>100 m)	21	0.700	0.365	35	0.484-0.916	+	0.605
Narrow ridge (≤100 m)	1	0.033	0.146	14	-0.051-0.117	_	-0.667
Wide ridge (>100 m)	2	0.067	0.354	34	-0.051-0.185	-	-0.768
Hillside	2	0.067	0.083	8	-0.051-0.185	=	

^aOverall $\chi^2 = 17.021$, 4 df, P = 0.002.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

Table 6. Selection of relative position on slope during summer by roosting male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Relative position on slope	Use n	Observed proportion	Available proportion	Available n	Bonferroni confidence interval ^a	Selection ^b	Jacobs' D
Upper third	20	0.667	0.424	39	0.461-0.873	+	0.463
Mid third	8	0.267	0.326	30	0.074-0.460	===	
Lower third	2	0.067	0.250	23	-0.042-0.176	-	-0.646

^aOverall $\chi^2 = 6.724$, 2 df, P = 0.035.

Dietary Selection

On CSA, we collected 19 fecal samples in 1996 and 17 fecal samples in 1997. On MLSA, we collected 24 and 27 fecal samples in 1996 and 1997, respectively. The 5 dominant items within the diet were forbs, grasses, juniper berries, Gambel oak acorns, and ponderosa pine seed (Appendix 7). Diet composition of dominant items did not differ between years in either study area (minimum Mann-Whitney UP > 0.251 on CSA, minimum Mann-Whitney UP > 0.190 on MLSA). Diet composition did not differ between CSA and MLSA (minimum Mann-Whitney UP >0.10), although amount of available ponderosa pine seed and juniper berries at feeding sites differed between the 2 study areas (Mann-Whitney UP = 0.018 and 0.008, respectively) and the amount of ponderosa pine seed at random plots differed between study areas (Mann-Whitney UP = 0.022). Because differences in food availability between study areas were small (median ponderosa pine seed at feeding sites: CSA 0.840 gm/m², MLSA 0.148 gm/m²; median juniper berries at feeding sites: CSA 0.000 gm/m², MLSA 0.000 gm/m²; median ponderosa pine seeds at random plots: CSA 0.544 gm/m², MLSA 0.213 gm/m²), we assumed that these differences

were not biologically meaningful. We therefore pooled these data to calculate proportions of food groups available to turkeys for diet comparisons.

We found little evidence of third-order selection when comparing availability of dietary items at feeding sites and random plots. Feeding sites and random plots differed only in availability of ponderosa pine seed; turkeys avoided this resource in selection of feeding habitats (D = -0.110, Table 10). No other dietary item we measured differed between random plots and feeding sites.

We found substantial differences between dietary items in corrected diets and availability at feeding sites (fourth-order selection). Turkeys selected less grass in the diet although it dominated food items available at feeding and random plots (D = -0.952, Table 10). Ponderosa pine seed was also avoided (D = -0.672). Conversely, forbs were strongly selected (D = 0.913), although they composed only small proportions of feeding sites and random plots. Insects, juniper berries, and Gambel oak acorns were selected and consumed in detectable quantities, although their presence was not detected in our availability sampling efforts.

Table 7. Selection of habitats in association with some form of human-induced trail or road during summer by roosting male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Proximity to trail or road	Use n	Observed proportion	Available proportion	Available n	Bonferroni confidence interval ^a	Selection ^b	Jacobs' D
>100 m	27	0.931	0.518	49	0.826-1.036	+	0.852
$\leq 100 \text{ m}$	2	0.069	0.482	46	-0.036-0.174	-	-0.852

^aOverall $\chi^2 = 16.147$, 1 df, P < 0.001.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

Table 8. Logistic regression models (logit scale) describing summer habitat selection by male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

		n					dictions correct)	•
Model	Use	Random	χ^2	P	Logistic regression models	Use	Random	Overall
Roosting	30	30	35.536	<0.001	$\hat{\mathbf{Y}} = -6.614 + 1.435\text{CT1}^{\text{a}} + 0.160\text{PPBA}^{\text{b}} + 0.101\text{SLOPE}^{\text{c}}$	82.1	79.2	80.8
Loafing	18	18	15.683	< 0.001	$\hat{\mathbf{Y}} = 1.384 + 0.241\text{CT3}^{d} - 0.498\text{HERBHT}^{e}$	77.8	72.2	75.0

^aPercent ground cover provided by conifer trees between 0-45.9 cm above ground.

Summer Use Areas

We obtained >5 summer locations on each of 5 male turkeys on CSA and 9 on MLSA. On CSA, we acquired a mean of 26.2 (range 15-38) locations per bird. Although we obtained samples on more birds on MLSA, the mean locations per bird was only 9.6 (range 6-12). The mean area encompassed by a minimum convex polygon surrounding summer locations for turkeys on CSA was 60.8 km^2 (SE = 15.9; Fig. 2), while area covered by the minimum convex polygons on MLSA was 33.8 km^2 (SE = 17.2, Fig. 3). However, minimum convex polygon size surrounding summer use areas did not differ between the CSA and MLSA (t = -1.1493, 11 df, P = 0.275).

Survival

Survival rates by age varied among years for male turkeys on CSA and MLSA (Table 11). Mean annual survival for adult male turkeys on CSA was higher than that on MLSA (Z = 2.664, P = 0.004; Table 12), whereas yearling male survival rates did not differ (Z = 0.354, P = 0.363). The lowest annual survival by adult males on the CSA was 0.604 during 1995. Adult males on MLSA during that same year experienced 0.192 survival. Adult male survival on MLSA peaked at 0.722 during 1997. Yearling survival on MLSA ranged from 0.385 to 0.542. Yearling survival on CSA ranged from 0.000 to 1.000, but these estimates were unreliable because we had marked only a single subadult male.

Table 9. Selection of stand with canopy closure at site center during summer by loafing male Merriam's turkey on the Chevelon and Mormon Lake study areas, Arizona, 1995-97.

Closed overhead canopy	Use n	Observed proportion	Available proportion	Available n	Bonferroni confidence interval ^a	Selection ^b	Jacobs' D
Absent	3	0.167	0.573	55	-0.030-0.364	_	-0.740
Present	15	0.833	0.427	41	0.636-1.030	+	0.740

^aOverall $\chi^2 = 17.739$, 1 df, P < 0.001.

^bPonderosa pine basal area (m²/ha).

^cPercent slope.

^dPercent ground cover provided by conifer trees between 92-184 cm above ground.

^eMean height (cm) of herbaceous vegetation on 0.04 ha plot.

b+ denotes selection, - denotes avoidance, and = denotes use consistent with availability.

Table 10. Composition, probabilities of differences, and selection between male diets and measured availability during summer (May 15-September 15) on the Chevelon and Mormon Lake study areas, Arizona, 1996-97.

Diet item	Kruskal- Wallis P	Dietary composition (%)	Selection ^a index	Median feeding site composition (%)	Selection ^b index	Median random plot
Grass	<0.001	9.5°	-0.952	81.1 ^d		87.6° 9.3 ^d
Forb	<0.001 <0.001	81.1° 5.0°	0.913 0.999	16.4 ^d 0.0 ^d		9.3° 0.0°
Juniper berry Gambel oak acorn	< 0.001	1.2°	0.999	0.0^{d}		0.0^{d}
Ponderosa pine seed	< 0.001	0.5°	-0.672	2.5 ^d	-0.110	3.1°
Insect	< 0.001	2.7°	0.999	0.0 ^d		0.0^{d}

^aJacobs' D selection index (Jacobs 1974) between dietary items and feeding sites.

We identified 4 biological seasons based on periods of similar survival (Table 13). Survival rates remained stable during winter months (November to March) and summer months (June to September). Survival during each period encompassing a hunting season remained stable as well, although most survival rates between the fall and spring hunting season differed...

Seasonal trends were evident in male turkey survival (Table 13). Yearling male survival rates were lowest in winter. Adult male survival rates were lowest during the spring hunting period. No radio-marked male turkeys in our study were harvested during the fall hunting period. Survival functions from male turkeys on CSA were stable, but the stability probably reflected small (3-5 radio-marked turkeys) sample sizes (Fig. 4). Yearling and adult males exhibited differing survival rates across the year. MLSA survival functions indicated mortality occurred consistently throughout the year, although mortality during spring hunt periods was greater in magnitude for adults (Fig. 5). Mortality that occurred during the spring hunt period was the major difference between the distributions of adult and yearling males on MLSA.

We detected little difference between mean annual mortality rates. Predation had a greater

effect on mortality rates of adult males on MLSA (Z=1.673, P=0.048; Table 12) than on CSA, whereas yearling predation-related mortality rates did not differ between study areas (Z=0.672, P=0.251). Hunting mortality rates did not differ between study areas for either adult or yearling male turkeys (Z=1.631, P=0.052 and Z=1.470, P=0.071, respectively).

Population Modeling

Sensitivity Analysis. Mean values from previous studies on the CSA for parameters entered into the deterministic model resulted in a stable population estimate among years. Adult survival had the greatest impact on the population 10 years in the future, while yearling nesting rate had the smallest effect (Table 14).

Stochastic Modeling. Stochastic models differed substantially in population performance (Table 15). The population modeled for CSA showed the greatest tendency for marked declines. Populations modeled using nesting rates reported for the Black Hills, South Dakota, and improved survival rates on CSA had the greatest tendency to increase. Even the CSA population modeled with yearling nesting rates equal to adult nesting rates showed a marked tendency to increase.

^bJacobs' D selection index (Jacobs 1974) between feeding sites and random plots.

^{cde}Median composition values with the same letter do not differ based on a median separation procedure (Miller 1966:166).

Relative Population Status

Fewer turkeys were observed on CSA than MLSA each year. On CSA, 0, 6, and 33 turkeys were observed annually on surveys during 1995-97. Sixty-two, 13, and 55 were observed during the same period on MLSA. We consistently

observed more turkeys on MLSA, although the magnitude of the difference and years of high and low observations were not consistent between study areas.



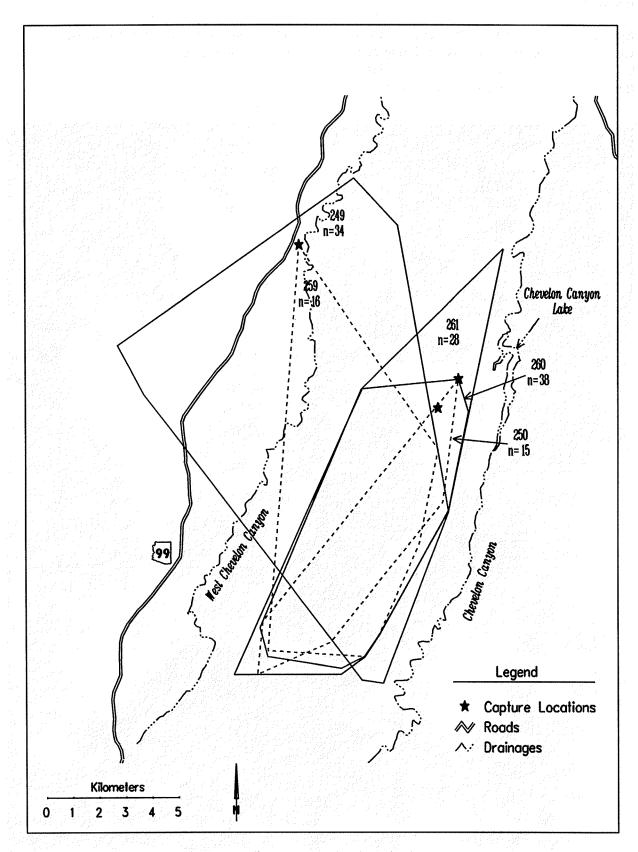


Figure 2. Minimum convex polygons surrounding summer use locations of male turkeys, animal identification numbers, and sample sizes on the Chevelon study area, 1995-97.

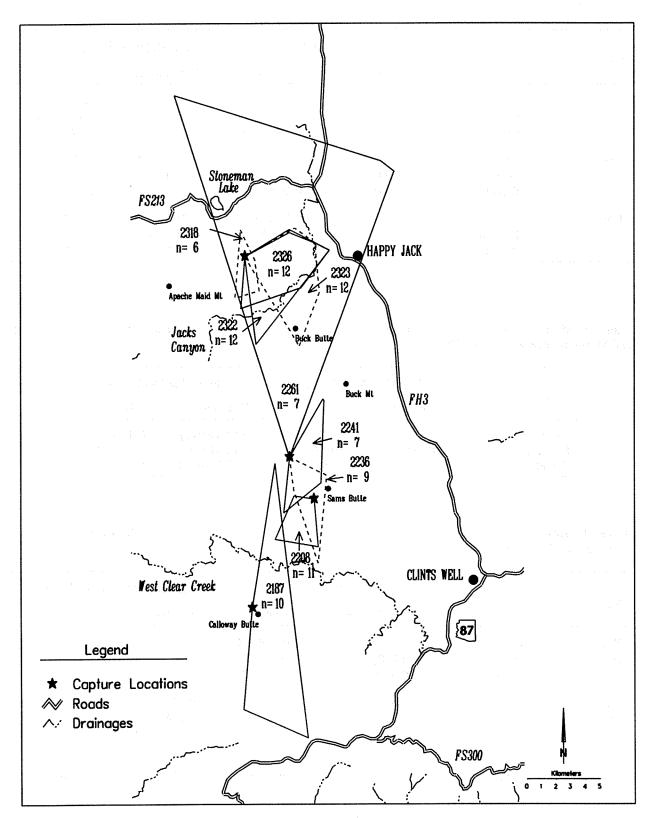


Figure 3. Minimum convex polygons surrounding summer use locations of male turkeys, animal identification numbers, and sample sizes on the Mormon Lake study area, 1995-97.

Table 11. Annual survival and mortality rates (variance) for yearling and adult male turkeys on the Chevelon and Mormon Lake study areas, 1995-97.

		Chevelon s	study area	Mormon La	ke study area
Year	Class	Yearling rate	Adult rate	Yearling rate	Adult rate
1995	Survival		0.604(0.093)	_	0.192(0.027)
	Hunting	•	0.396(0.093)	-	0.461(0.043)
	Predation	-	0.000(0.000)	-	0.347(0.039)
1996	Survival	1.000(0.000)	1.000(0.000)	0.542(0.019)	0.404(0.014)
	Hunting	0.000(0.000)	0.000(0.000)	0.067(0.004)	0.258(0.010)
	Predation	0.000(0.000)	0.000(0.000)	0.391(0.019)	0.338(0.013)
1997	Survival	0.000(<0.001)	0.796(0.033)	0.385(0.135)	0.722(0.028)
	Hunting	0.000(0.000)	0.000(0.000)	0.615(0.135)	0.139(0.017)
	Predation	0.999(0.000)	0.204(0.033)	0.000(0.000)	0.139(0.017)

Table 12. Mean annual survival and mortality rates (variance) for yearling and adult male turkeys on the Chevelon and Mormon Lake study areas, 1995-97.

Class	Chevelon study area		Mormon Lake study area	
	Yearling rate	Adult rate	Yearling rate	Adult rate
Survival	0.387(0.135)	0.825(0.013)	0.525(0.017)	0.439(0.008)
Hunting	0.000(0.000)	0.088(0.007)	0.123(0.007)	0.274(0.006)
Predation	0.613(0.135)	0.088(0.007)	0.352(0.016)	0.286(0.007)

Table 13. Seasonal interval survival and mortality rates (variance) for yearling and adult male turkeys on the Chevelon and Mormon Lake study areas, 1995-97.

Year		Chevelon study area		Mormon Lake study area	
	Class	Yearling rate	Adult rate	Yearling rate	Adult rate
Winter	Survival	0.381(0.135)	1.000(0.000)	0.709(0.020)	0.767(0.008)
(Nov-Mar)	Hunting	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
()	Predation	0.619(0.135)	0.000(0.000)	0.291(0.020)	0.233(0.008)
Spring hunt	Survival	1.000(0.000)	0.813(0.014)	0.846(0.010)	0.605(0.008)
(Apr-May)	Hunting	0.000(0.000)	0.093(0.008)	0.154(0.010)	0.324(0.008)
	Predation	0.000(0.000)	0.093(0.008)	0.000(0.000)	0.072(0.002)
Summer	Survival	1.000(0.000)	1.000(0.000)	0.766(0.021)	0.874(0.007)
(Jun-Sep)	Hunting	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
(carit m'sb)	Predation	0.000(0.000)	0.000(0.000)	0.234(0.021)	0.126(0.007)
Fall hunt	Survival	1.000(0.000)	1.000(0.000)	1.000(0.000)	1.000(0.000)
(Oct)	Hunting	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
(00)	Predation	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)

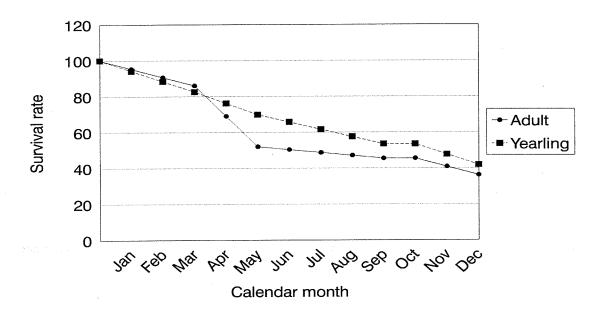


Figure 4. Annual survival distributions for radio-marked yearling and adult male turkeys on the Chevelon study area, Arizona, 1995-97.

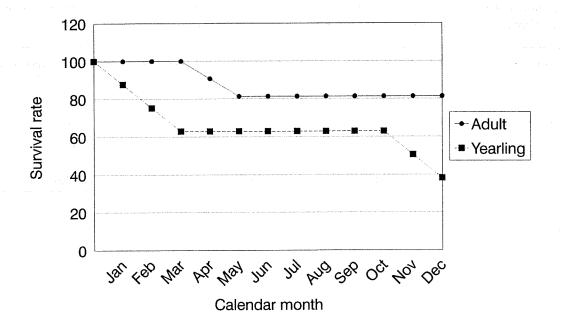


Figure 5. Annual survival distributions for radio-marked yearling and adult male turkeys on the Mormon Lake study area, Arizona, 1995-97.

Table 14. Population model parameters and effect on population estimate 10 years in the future by altering each parameter by 10% within the deterministic population model.

Population parameter	Percent change to population 10 years in futu	ire
Adult survival	37.5%	
Yearling survival	21.9%	
Juvenile survival	23.1%	
Adult nesting rate	25.3%	
Adult nesting success	26.3%	
Yearling nesting rate ^a	11.1%	
Poult survival	26.3%	
Number of eggs	25.3%	

^aEstimate derived by including a yearling nesting rate of 0.5 within the deterministic equation, a parameter not included in the initial model.

Table 15. Stochastically modeled population performance 10 years in the future (percent of 500 simulations) relative to the beginning population level based on parameters measured on the Chevelon study area, Arizona (CSA), the addition of nesting parameters measured in the Black Hills, South Dakota (Black Hills), the addition of yearling nesting rates equal to adult nesting rates documented on CSA (CSA with yearling nesting), and improved survival of yearlings and adults by 0.2 on CSA (CSA with improved survival).

Performance	CSA	Black Hills	CSA with yearling nesting	CSA with improved survival
>20% decline	63%	0%	7.0%	0%
≤20% decline	15%	0%	7.4%	0%
≤20% increase	11%	0.6%	5.8%	0.8%
>20% increase	11%	99.4%	79.8%	99.6%





DISCUSSION

Habitat Selection

Feeding Sites. We detected little third-order selection with respect to feeding sites. This indicates that male turkeys feed more opportunistically during summer than at other times of the year. Wakeling and Rogers (1995b) found that turkeys were more selective in locating feeding sites during late winter than during early winter. They speculated that greater third-order selectivity for feeding sites during late winter resulted from reduced food availability at feeding sites (fourth-order selection limitations) and a subsequent greater need to be more selective to find feeding sites that provided adequate food. Third-order selection for feeding sites may become more pronounced in periods with limited food availability.

Male turkeys seem to feed less selectively during summer than did females. Females and females with young demonstrated greater thirdorder selection in their use of feeding habitat during summer (Rumble and Anderson 1993b, 1996a; Mollohan et al. 1995) than male turkeys did during our study. Small (<1 ha) openings with greater herbaceous cover and species richness were commonly selected by females, associated with marked edge contrasts to the opening that provide escape cover. Large (>1 ha) openings and meadows were not selected. Foods selected by female turkeys and females with young tend to change as summer progresses (Rumble and Anderson 1996b), and characteristics of the habitats selected tend to change with it. Again, specific fourth-order selection for certain food items seems to influence third-order selection for feeding sites by females.

The association of feeding sites with human-induced trails or roads may reflect turkey use of trails and roads that facilitate access to feeding sites and feeding habitat, or herbaceous food may simply be more abundant immediately adjacent to roads. Type of trail or road in close proximity to the feeding site was generally a low-grade road with limited traffic. Rogers et al. (In review) found that turkeys avoid the first 200 m surrounding roads that are used by vehicles multiple times daily. While disturbances that occur on high traffic roads are apparently undesirable, physical attributes of roads may

favor herbaceous production or provide access to suitable feeding habitat.

Although unlikely, association of male turkeys with human-induced roads and trails may be an artifact of the manner in which data were collected; we often used roads and trails to access radio-marked turkeys. But, observation of radiomarked turkeys generally required leaving vehicles, roads, and trails and walking across broken country. Roads and trails that turkeys fed in proximity to were often impassable by motorized vehicles. In addition, we did not detect a similar association of roads or trails with other types of male turkey use sites. While the possibility exists that association of male turkey feeding habitats with roads was an artifact of the manner in which we collected habitat use data, we do not believe this was likely.

The CSA and MLSA differed in some habitat components that, although they did not influence habitat selection during summer, probably would influence habitat selection during winters. The greater amount of Gambel oak and juniper on MLSA may play a critical role in winter nutrition and body condition by providing greater quantities of favored winter foods important to overwinter survival (Wakeling 1991, Wakeling and Rogers 1995b). MLSA also had greater canopy completeness than did the CSA, a characteristic commonly selected in many winter and summer use sites.

Roosting Sites. Results from our summer roosting site selection work supports findings from other published studies. Merriam's turkeys consistently select large (>50 cm) DBH ponderosa pine trees and stands with high (>20 m²/ha) ponderosa pine BA (Scott and Boeker 1977; Phillips 1980; Rumble 1992; Mollohan et al. 1995; Wakeling and Rogers 1995b, 1996). Roosting sites are commonly located near the top of steep slopes in other studies as well. Association of roosting sites in our study with more Gambel oak than random plots can probably be explained because Gambel oak is commonly located within canyons, and summer roosting sites were frequently associated with a canyon. However, male turkeys did not actually roost within Gambel oak trees. Male turkeys selected roosting sites similar to those selected by female turkeys in other studies.

Turkeys roosted in forest stands that had various levels of silvicultural treatment. We

could not determine if turkeys select roosting sites prior to treatment and continue to use them afterward, or simply select the site for roosting some years after silvicultural treatment. A BA of 21 m²/ha and a minimum tree DBH of 50 cm is commonly recommended for roosting site management (Phillips 1980, Rumble 1992, Mollohan et al. 1995, Wakeling and Rogers 1995b, Flake et al. 1996). BA at roosting sites in our study averaged 21.2 m²/ha, and mean tree DBH was 52.8 cm, further supporting those guidelines. We also found that clumpy canopies are important to selection of roosting sites, which supports the findings of Mollohan et al. (1995). Because of the advanced age of trees at roosting sites and difficulty of recruiting suitable alternate stands, most habitat recommendations concerning roosting site management advocate no silvicultural treatment (Phillips 1980, Hoffman et al. 1993, Mollohan et al. 1995).

Turkeys favored wide canyons and steep (>30%) slopes in roosting site selection. This selection is consistent with observations in other studies (Jonas 1966, Lutz and Crawford 1987, Mollohan et al. 1995), although some studies have found turkeys to roost on gentler (15-20%) slopes (Scott and Boeker 1975, Rumble 1992). Hoffman (1968) and Lutz and Crawford (1987) found that summer roosting sites were on gentler slopes than winter roosting sites, but summer roosting sites in our study did not differ in slope from winter roosting sites on the same area (Wakeling and Rogers 1995b). Slope and land form selection may have been influenced by the availability of forest stands with suitable characteristics (large DBH and BA) that may have been more available on slopes in canyons on our study areas.

Loafing Sites. Summer loafing site selection by male Merriam's turkeys is similar to that selected by females and females with young as described by Mollohan et al. (1995). Importance of canopy closure, overhead conifer cover, presence of downed wood, and association with a slope were documented in both female and male turkey loafing habitat selection. Increased canopy closure is often associated with decreased herbaceous production (Uresk and Severson 1989), a characteristic we also observed at loafing sites.

The role of loafing habitat and loafing activities in turkey ecology is poorly understood (Wakeling and Rogers 1996). Loafing habitat

may be used for resting and turkeys may engage in this activity when nutritional needs have been met, or this type of habitat may be used to minimize thermal loading. Many attributes of loafing habitat (closed canopy, further from openings) are characteristic of habitats that provide shade. However, this does not eliminate the possibility that nutritional needs of a turkey must be met before loafing activities occur. Regardless, loafing habitat seems to be important to both genders of turkeys during summer.

Dietary Selection

We detected little evidence of third-order selection for dietary items. Wakeling and Rogers (1996) found more evidence of third-order selection of dietary items during late winter than during early winter, when food sources were more abundant. We believe a similar relationship exists for male turkeys in summer. Dietary items were relatively abundant and likely more evenly distributed, and little selection was evident in quantities of dietary items within feeding sites when compared to random plots.

Fourth-order selection was more apparent than third-order selection for dietary items during summer, as it was during early and late winter (Wakeling and Rogers 1996). Turkeys favored forbs, whereas they selected grasses in smaller proportions than available. The high degree of selection for some mast items is a result of small availabilities; small availabilities tend to artificially inflate Jacobs' D index (Lechowicz 1982). Although mast items are important to turkeys during winter (Rumble 1990; Wakeling and Rogers 1995b, 1996; Rumble and Anderson 1996b), these items are of less importance to turkeys during summer. Mast items have greater caloric content than do grasses and forbs (Decker et al. 1990, Rumble 1990). But, because mast items are predominately produced during fall and winter, availability diminishes prior to summer. Further, availability of other important dietary items, such as forbs and grasses, increases during summer. Consequently, herbaceous material dominates the diet of male turkeys during summer.

Comparisons among dietary studies of turkeys should be made with caution, as few have corrected for differential digestibility of dietary items. Herbaceous material differs in digestibility from most hard mast items (Rumble and

Anderson 1993a). Forbs tend to be highly digestible, whereas grasses have lower digestibility, which results in underrepresentation of forbs and overrepresentation of grasses in microhistological estimates of diet composition from feces. Mast items, because of their low surface area to volume ratio, are often underrepresented in the estimate of diet composition as well. Further, juniper berries differ from most mast items because they have identifiable internal scleroids, which results in overrepresentation in the diet. In short, uncorrected diets estimated from microhistological analyses of feces have substantial inherent biases (Rumble and Anderson 1993a). Because diets were not corrected for differential digestibility on previous diet studies on the CSA (Wakeling and Rogers 1995b, 1996), ponderosa pine seed, Gambel oak acorns, and forbs were probably underrepresented in those studies.

Turkeys have been described as opportunistic feeders (Hurst 1992). Our study and those of Wakeling and Rogers (1995b, 1996) suggest that they forage opportunistically at a third-order level, except when dietary items are limited in availability. But at fourth-order scale, turkeys are selective of the items consumed. Turkeys select favored food sources spatially and temporally (Wakeling and Rogers 1995b, Rumble and Anderson 1996b).

Although grasses were selected in lower proportions than available in our study and in studies of Wakeling and Rogers (1995b, 1996), diets of male turkeys still include a substantial proportion of grasses. Grass foliage is common in turkey diets from the Southwest (Scott and Boeker 1973, Schemnitz et al. 1985), but grass seeds are more predominate in turkey diets from South Dakota (Rumble and Anderson 1996b) and Wyoming (Hengel 1990). Grass seeds composed a small proportion of male turkey diets in our study.

Capture and Summer Use Areas

Body weight and home-range size typically relates to habitat quality (Ables 1969, Brown 1980, McNab 1963). Generally, in high quality habitat, we would expect heavier body weights and smaller home ranges. We did not observe differences in either body weight or summer activity areas between CSA and MLSA. This

information suggests that habitat quality between the 2 study areas is similar, although the small number of relocations on MLSA turkeys and the small sample of marked CSA turkeys reduced our ability to detect differences (Brown 1980).

When compared with home ranges of other subspecies in other habitats, Arizona's Merriam's turkeys used substantially larger areas. Seasonal movements for Rio Grande turkeys (*M. g. intermedia*) may be as much as 42 km, but average about 17 km (Thomas et al. 1966, 1973). Eastern turkeys (*M. g. silvestris*) commonly use <15 km² for annual activities (Everett et al. 1979, Martin 1984, Smith et al. 1989, Godwin et al. 1996). Summer use areas for male Merriam's turkeys averaged 43.4 km². Annual home ranges for female turkeys on CSA ranged from 102.9-152.8 km² (Wakeling 1991).

Survival

Winter is the period when yearling males experience their lowest survival. Similarly, female turkeys on CSA experience lowest survival during winter (Wakeling 1991). Although only weak relationships between mast availability and fall-winter survival have been documented (Wakeling 1991, Vangilder 1996), Porter et al. (1980) demonstrated that turkeys with access to corn food plots had greater survival during severe winters than those with no access. Greater nutritional fitness apparently improves turkey overwinter survival. Predation accounted for most of the mortality we observed on yearling males; nutritional status may influence vulnerability of turkeys to predation.

Peak mortality period and primary cause of death differed between adult and yearling male turkeys. Unlike other age or gender classes, adult males experience lowest survival during the spring hunt period. Spring hunting accounted for about 50% of the annual mortality in adult males during our study, whereas only 33% of yearling mortality was attributed to spring hunting. Vangilder (1996) documented that hunting accounted for 30% of male turkey mortality in the Missouri Ozarks. Paisley et al. (1996) found that hunting was the leading cause of death for male turkeys in Wisconsin.

Population modeling by Kurzejeski and Vangilder (1992) suggests that harvesting >25% of adult males each year could shift the age structure of the population toward younger males.

Paisley et al. (1996) found no difference between mortality of yearling and adult male turkeys due to hunting in a population they believed to be overexploited. They also noted a declining trend in proportion of adult males in the spring harvest during the period of believed overexploitation. We did not collect data on the age structure of unmarked turkeys harvested during spring hunts, but survival of adult males was influenced more by spring hunting than was survival of yearling males. This suggests that turkey populations on our study area were not overexploited by the spring hunt.

Our 2 study areas differed somewhat in topography, a factor that may influence male turkey vulnerability to harvest during spring hunting periods. Because turkeys select steep slopes for roosting, some hunters seek out this characteristic in habitat when pursuing turkeys during the spring hunt. Hunters typically use some type of artificial call to attract males during spring hunts, and turkeys often respond to calls from roosting sites either in early morning or late at night. MLSA has numerous hills and cinder cones, topographic features lacking on CSA, where turkeys commonly roost, associated with a network of moderate quality roads. This association may facilitate increased harvest by spring turkey hunters. Spring harvest in habitats where turkeys are suspected of being more vulnerable should be monitored to detect evidence of overexploitation.

Although male turkeys are frequently harvested during spring, yearling and adult male turkeys are rarely harvested during the fall hunt. Typically, yearling and adult males comprise ≤10% of the fall harvest (R. Engel-Wilson, Ariz. Game and Fish Dep., unpubl. data); none of our radio-marked males were harvested during the fall hunt. Limited harvest of male turkeys during the fall is common (Paisley et al. 1996), although the proportion harvested increases in areas with fall hunting seasons that approach a month in length (Little et al. 1990, Vangilder 1996).

Population Modeling

The sensitivity analysis showed that any demographic parameter altered by 10% can have a substantial effect within 10 years. Turkey populations are highly dynamic and may fluctuate by as much as 50% between years (Mosby 1967), although such magnitude of change is unlikely

(Roberts and Porter 1996). Nonetheless, marked changes are common in many demographic parameters between years in Arizona (Wakeling 1991, Mollohan et al. 1995). Still, because turkey populations are difficult to index, knowledge of the actual magnitude and frequency of annual fluctuations is limited.

Simulated demographic parameters had different effects on modeled populations. Simulated adult survival had the greatest effect, probably because this comprised the largest cohort in the model. Changes in simulated yearling nesting rate had the smallest effect on the modeled population. However, because southwestern turkey populations typically have little yearling nesting effort, greatest potential for improvement exists in this demographic parameter. We are aware of only a single documented yearling nest within Arizona (Crites 1988), although Lockwood and Sutcliffe (1985) documented nesting by 8% of marked yearling females in New Mexico. Based on stochastic modeling, increases in yearling nesting rates can substantially increase turkey population densities.

Yearling Merriam's turkey females are known to nest at considerably greater rates than that measured in the Southwest. Substantial yearling nesting has been noted in Colorado, Wyoming, South Dakota, and Montana (Hengel 1990, Rumble and Hodorff 1993, Thompson 1993, Hoffman et al. 1996), whereas other parts of Colorado, New Mexico, and Arizona have limited or no yearling nesting (Lockwood and Sutcliffe 1985, Hoffman 1990, Wakeling 1991). In habitats with yearling nesting, subadult females average about 0.5 kg heavier during mid-winter than those from habitats with limited yearling nesting (Hoffman et al. 1996). The heavier turkeys generally had access to supplemental feeds during winter, whereas lighter birds did not (Hoffman et al. 1996).

Although we have not modeled stochastic weather cycles like multi-year droughts, effects from an event that negatively influences recruitment may be speculated. Because Arizona's turkey recruitment is limited, these populations may be fragile and easily impacted. If unfavorable climatic conditions ultimately influences reproductive performance, multiple years of poor reproductive performance could considerably reduce turkey numbers.

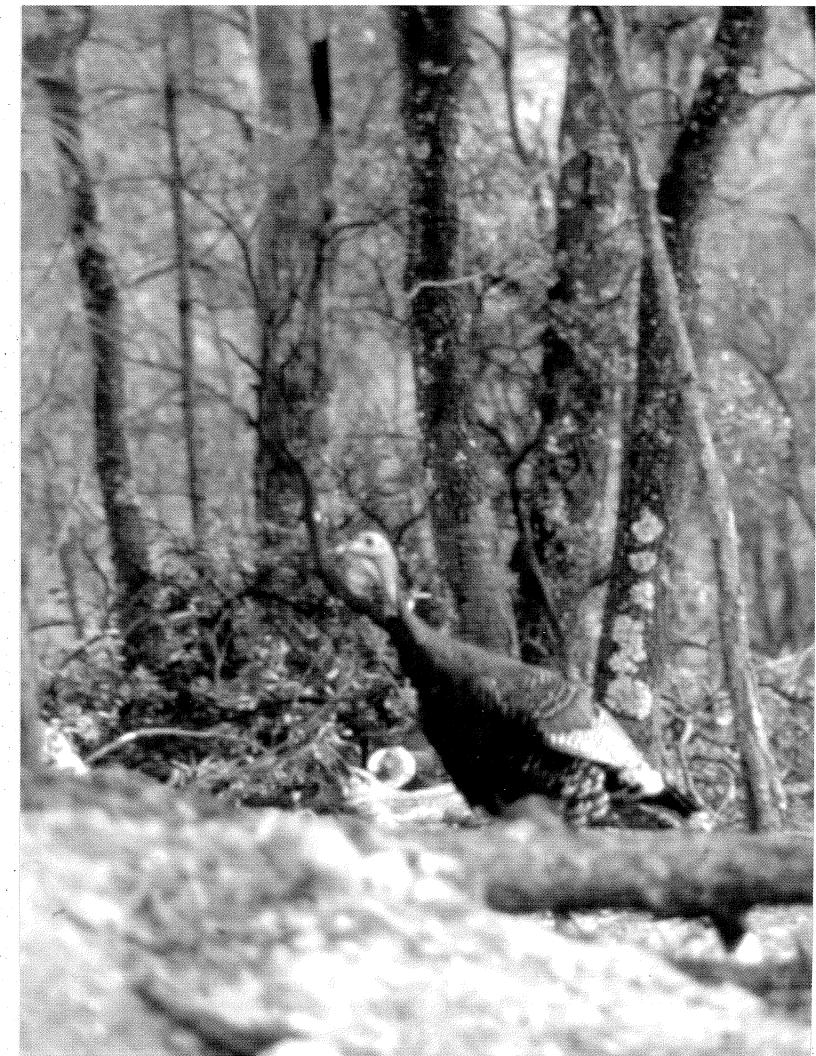
Assumptions of our model may not all be

accurate. Demographic parameters may not be truly independent. For example, reproductive performance may be influenced by population density (Porter 1978), predation (Glidden 1977, Vander Haegen et al. 1988), weather (Beasom and Pattee 1980, Porter et al. 1983), habitat quality (Lockwood and Sutcliffe 1985, Wakeling et al. 1998), or disease (Rocke and Yuill 1987). Survival rates may vary dependently among age classes. Conversely, other assumptions seem accurate. For instance, demographic parameters seem random in distribution, rather than normally distributed (Vangilder 1992). We recognize that our models may not accurately reflect the true magnitude in population changes, but we believe that implications of changes to demographic parameters in our model and their effect on the population are correct.

Relative Population Status

The magnitude and consistency in differences in turkey numbers observed between CSA and MLSA suggest that MLSA supports a higher density population than does CSA. Habitat characteristics such as the density and cover provided by oaks and junipers on the MLSA indicate that it may be superior to CSA for

providing suitable winter habitat (Wakeling and Rogers 1995b, 1996), that might in turn improve overwinter survival of females, increase nesting rates, and increase nesting success. However, apparent differences in density between the 2 study areas should be interpreted with caution for several reasons. First, we had insufficient samples to statistically evaluate the relationship. Second, Shaw (1973) demonstrated that observations of 50-100 birds were needed to obtain the power to detect year-to-year changes of 20% in young: female ratios at the 80% confidence level. We rarely approach that level of observation on CSA, and occasionally do not meet such levels on MLSA. Finally, this type of survey is designed to primarily provide an estimate of young:female ratios. Even this ratio may be misleading for comparisons between areas because the proportion of yearling females within the population, which cannot be distinguished from adult females, may vary markedly among habitats and years. Since yearlings typically do not nest in the Southwest, and proportion of yearlings is generally not known, this can strongly influence estimates of young:female ratios (Wakeling 1991).



MANAGEMENT IMPLICATIONS

Habitat

Turkeys are dependent on multiple successional stages to meet their annual needs. Thus, yearlong needs of turkeys must be considered when evaluating habitat capabilities. Summer feeding sites for both male and female turkeys tend to be early successional in nature. Loafing habitat is commonly mid-seral, with little herbaceous cover within the site. Loafing sites are generally small (≤ 0.5 ha), surrounded by small (≤ 0.5 ha) openings (early seral) that may be used for feeding. Winter feeding sites are often mature stands of mast-producing trees. Roosting sites are mature, late-seral stands of conifers, typically ponderosa pine.

Feeding Habitat and Foods. Feeding habitat selection is driven primarily by preferred food availability (fourth-order selection). Characteristics of feeding sites are important (third-order selection), but secondary in feeding site selection. Important considerations when managing feeding habitat include:

- Forbs and insects are important components of summer diets. When reseeding, include an even mix of forbs and grasses. Herbaceous areas provide abundant invertebrates as well as vegetative foods for turkeys.
- Selective silvicultural treatments typically result in small (<0.25 ha) herbaceous openings that serve as feeding habitat. Reseed these types of openings as needed to provide summer feeding habitat.
- Close unnecessary roads. Although turkeys feed on closed roads, roads that receive regular vehicular traffic are avoided by turkeys. If a road is closed, disturb and reseed the roadbed if necessary to encourage herbaceous production.
- When possible, encourage sharp edge contrasts to feeding openings. Shrubs or lowhanging conifer branches provide excellent edge contrast to openings. This contrast will provide hiding cover for turkeys feeding within the opening.

- Winter feeding habitat is comprised of mature mast-producing trees. Diversity and dependability of mast crops dictates the quality of the winter range as feeding habitat.
- Feeding habitat should be located <1.6 km from roosting habitat. Silvicultural treatments that reduce the suitability of feeding habitat below thresholds acceptable to turkeys can result in abandonment of feeding habitat and associated roosting sites.

Roosting Habitat. Because daily activities of turkeys are associated with roosting site proximity, roosting habitat management can strongly influence turkey habitat use. Important considerations in roosting habitat management include:

- Roosting sites are typically clumps of mature ponderosa pine 0.25-0.6 ha in size.
- Roosting site BA averages >21m²/ha.
- Individual roost trees are usually >50 cm DBH.
- Roosting sites are generally located at the upper third of >30% slopes.
- Optimum roosting site density is ≥0.8 sites/km². Efforts to recruit new roosting sites should be undertaken if densities are below the recommended level.
- Most daily activities of turkeys occur within 1.6 km of roosting sites, especially during winter.
- Roosting sites may be abandoned if land management activities substantially alter surrounding turkey habitat.
- Roosting sites are used traditionally. Even summer roosting sites are used repeatedly within the same season and during subsequent years. Roosting sites may be abandoned temporarily due to disturbance and changes in food resource availability.
- All known turkey roosting sites should be protected during silvicultural treatments.

 Our logistic regression model may be used to identify potential roosting sites if known roosting sites are fewer than desired.

Loafing Habitat. Although the role of loafing in turkey ecology is poorly understood, we believe that managing for loafing habitat is important. Turkeys consistently select specific habitat attributes at sites where they loaf. Important considerations in loafing habitat management include:

- Turkeys typically loaf within small (<0.25 ha) clumps of intermediate size (15-25 cm DBH) trees.
- Loafing clumps typically have large (>28 cm DBH) downed logs or rock outcrops within them. Those downed logs or rock outcrops serve as perches for loafing turkeys.
- Loafing sites are typically located adjacent to small (<0.25 ha) openings within which turkeys may feed. These openings typically have diverse and abundant herbaceous vegetation.
- Loafing sites generally have >50% canopy closure and little (<10%) herbaceous vegetation in the understory.
- Silvicultural treatments that produce a mosaic pattern of BAs, creating small openings while retaining stands >20m²/ha BA will favor retention of suitable loafing sites. Isolation of potential loafing sites from contiguous high (>18 m²/ha) BA stands discourages turkey use. Protecting individual loafing sites during silvicultural treatments would be difficult and unnecessary.
- Our logistic regression model may be used to identify suitable loafing habitat.

Populations

Survival and reproductive performance of turkey populations influences management. Although mean demographic parameters from Arizona turkey populations modeled in a deterministic fashion suggest that the CSA population was stable, stochastic modeling suggests that declines in the population are

common and probable. Two options become immediately apparent to affect increased population trends: improve survival or recruitment.

Survival. To increase survival of female turkeys, we must reduce hunting or natural mortality. Consider:

- populations. Although this approach seems likely initially, harvests of >5% of the female segment of the population have not been documented in Arizona. An even lower proportion of adult male turkeys are harvested in Arizona during the fall hunt. Generally, fall hunts must remove >10% of the population before impacts on turkey populations can be detected. Improving turkey survival by altering Arizona fall hunt does not seem promising.
- Reduce impacts of spring hunts on turkey populations. Similar to fall hunting mortality, spring hunting mortality must exceed a threshold before it is believed to impede a turkey population's capability to grow. Mortality due to spring hunting averaged below that threshold of 30%, and therefore should not be problematic. Because yearling spring hunt mortality rates were less than that for adults, we have further reason to believe overexploitation was not occurring. Although we have found no evidence to suggest that reducing spring hunting mortality would improve turkey population survival or trend, monitoring the proportion of adults and yearlings in the spring harvest in areas where excessive harvest might occur would provide data to base future management decisions. An overexploited population would be expected to exhibit a long term shift toward more yearling males in the harvest. If a shift were detected, harvest reductions would probably favor turkey populations. Age structure of the harvest might be monitored in 2 ways:
 - a. Spring hunter check stations. These check stations would probably only need to be monitored during the opening weekend of spring hunts. Age of turkeys could be discerned through beard length,

- leg length, or spur development (Heffelfinger 1997).
- b. Voluntary leg collection centers. These centers could be located throughout a hunt unit where hunters could voluntarily deposit legs from harvested turkeys.

 Spur development, leg length (Wakeling et al. 1997b), or toe length (Rumble et al. 1996) could be used to age legs deposited, although refinement of these techniques would probably be necessary.

A shift toward more subadult turkeys in the spring harvest might be difficult or impossible to detect during years following poor reproduction and recruitment. This shift should be monitored for long term shifts (3-5 years) and be considered a conservative indicator of overexploitation.

Reduce natural mortality. Predator control may be suggested as a means of reducing natural mortality. The difficulty with this approach is that, although most turkeys are ultimately killed by predators, other factors may predispose them to predation. Those factors include inclement weather, severe winters, vegetative changes to their habitats, and poor nutritional status. If predator numbers are reduced, turkey survival may not improve because they might die to other causes like malnutrition or exposure. Additionally, predator control would need to be conducted over large areas because turkeys typically range over 150 km² annually. Costeffective large-scale reductions in predator densities would be difficult to implement, especially within forested habitats that turkeys occupy. This is not a likely option.

Recruitment. To improve recruitment, we are primarily focusing on age-specific clutch size, nesting rate, and nesting success, although brood survival must be considered. The demographic parameter that has the greatest potential for improvement is yearling nesting. Yearling Merriam's turkey nesting occurs in areas where mid-winter body weights of subadult female turkeys are slightly heavier than those in Arizona, which implies that a nutritional relationship may exist. As such, we suggest that improving winter

nutrition of subadult females would probably have beneficial effects on older cohorts within the population as well. To improve winter nutrition, consider:

- Improve natural food sources. Ponderosa pine and Gambel oak mast are favored food items that provide relatively high calories. Retaining and enhancing mature mast-producing species within stands in close (<1.6 km) proximity to known winter roosting sites will favor turkeys. Encourage alternate mast-producing species as well. Juniper berries is not as high in quality as other mast, but proves to be a staple food item during most winters because it produces mast more regularly than many other species like pine and oak.
- Ensure adequate summer food resources. By entering the winter in good physical condition, turkeys may reach mid-winter in suitable physical condition and heavier body weight. Provide habitats with abundant herbaceous vegetation in small (<0.5 ha) openings. This vegetation should be evenly distributed between forbs and grasses. Protection from excessive ungulate grazing may be necessary, and grasses should be allowed to develop seed heads. Horizontal screening cover should be available at the edges of these openings.</p>
- Establish food plots. Plant natural or domestic food crops in winter habitats especially for wintering turkeys. Although this avenue would probably be costly, immediate effects on turkey populations would probably be realized.
- Routine winter feeding. Although this avenue would probably realize immediate effects, the cost of this approach might be greater than that for establishing food plots. In addition, this type of feeding might result in unwanted concentration of turkeys, increased predation, or increased habituation to humans. The possibility for disease transmission is increased in concentrated flocks. Food quality becomes important because turkeys are highly susceptible to aflatoxin, common in waste grain.



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APPENDIXES

Appendix 1. Descriptions of survey routes used to index relative population status on the Chevelon study area, 1995-1997.

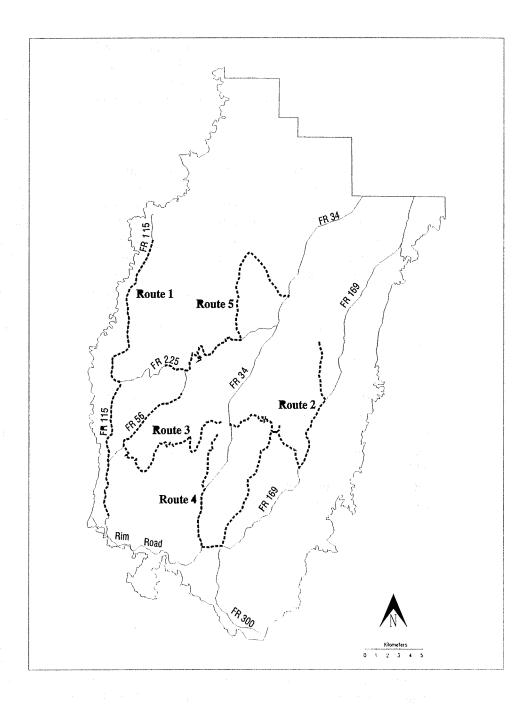
Route 1. From the junction of the 115 and 91 roads, drive 24 km north on the 115 road.

Route 2. From the junction of the 34 and 100 roads, follow the 100 road east 13.0 km to the junction of the 100 and 169 roads. Drive north 6.6 km to the junction of 169 and 213 roads. Drive northeast on the 213 road 4.5 km to the end of the route (24 km).

Route 3. From the northern junction of the 78 and 75 roads, drive west on the 75 road to its junction with the 89 road. Drive west on the 89 road to its junction with the 91 road. Follow the 91 road to its junction with the 40 road. Follow the 40 road to its junction with the 56 road. Follow the 56 road northeast to the end of the route (24 km).

Route 4. From the Vincent Ranch road on the 78 road, drive south on the 78 road to the junction with the 75 road. Follow the 75 road east to its junction with the 34 road. Follow the 34 road south to its junction with the 300 road. Follow the 300 road east to its junction with the 169 road. Follow the 169 road northeast to its junction with the 117 road. Follow the 117 road north to its junction with the 100 road. Follow the 100 road east to its junction with the 116 road. Follow the 116 road to the end of the route (24 km).

Route 5. From the junction of the 34 and 70A roads, drive east on the 70A road to its junction with the 70 road. Follow the 70 road west and south to the 225 road. Follow the 225 road west to the end of the route (24 km).



Appendix 2. Descriptions of survey routes used to index relative population status on the Mormon Lake study area, 1995-1997.

Route 1.

Begin route at a cattle loading chute about 2.5 km north on 132 road from its junction with the 90 road. Begin on road 6077 from 132, follow for 3.4 km, turn right at T in road. Follow another 1.3 km, remain on 6077 (not 6077C). Continue for another 1.9 km, turn right in front of stock tank. 2.7 km further turn left onto 132D road. Travel another 3.8 km and go straight over cattle guard, do not turn. Continue on 3.4 km and turn right on 132 road. Follow to 132A road, travel up this road 1.6 km, return to 132 road and turn left. Follow until you come to end (24 km).

Route 2.

Begin at Rocky Park exit on I-17, go to 80 road and travel south. Travel 1.1 km and turn left into tank. Turn around and go back to 80 road. Turn left and travel 2.6 km and turn left into tank. Turn around and go back to the 80 road. Turn right and travel 1.9 km to the 9563E road. Turn on the 9463E road and travel 0.5 km. Go straight, continuing on the 9463E road and travel 1.3 km to the fork. Take the left fork (9463H) and travel 1.1 km, stop at the 9463F road. Turn around and travel back to the 9463E road. Travel left 0.2 km to the 239 road. Turn left and travel 6.2 km to the 127A road. Turn left and travel 0.2 km to a fork and stay to the left and travel 1.8 km. As you come down a hill to a large meadow, turn right. Travel 1 km to a T, turn left and travel 1.6 km to 765 road. Turn right and travel 0.2 km to the 239 road. Turn right and travel 3.2 km to the 127A road (24 km).

Route 4.

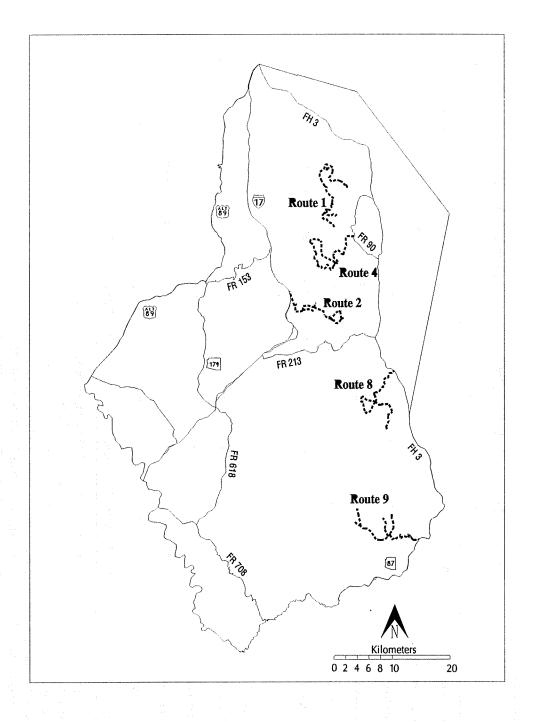
From the Mormon Lake road (90) and 90H, follow 90H for 7.2 km to 91 road. Follow 91 to Long Park and turn left. Follow for 1.4 km, cut across Long Park to old railroad grade, turn right and follow railroad grade for 4.6 km to 91A, then turn right and follow to 91 road. Turn left and follow 91 to 240 road. Follow 240 road 3 km and turn left onto 228 road. Follow 228 road until you reach a fork with a gate, turn thru the gate on the left and follow 2.2 km to Jones Tank. Go left at Tank and follow to 9466 road. Turn left on 9466 road and follow 0.8 km to 9495H. Stay right and go 1.4 km to Blackjack Tank. Follow around uphill to Girdner Tank. At T junction, turn left and follow back to Long Park. Turn right to go to 91 road. At 91, turn left and go to 90H (24 km).

Route 8.

Begin route at the cattle guard where the 305 road and FH3 intersect. Follow the 305 road 7.7 km to the junction of 229 and 305 roads. Turn right on the 229 road and follow for 2.7 km and turn left just beyond the cattle guard onto the unmarked road. Travel 0.8 km and take left fork. Travel 0.5 km and turn right. Travel 2.9 km and stay left. Travel 1.3 km and turn right on 229 road. Travel 3.8 km and turn right on 229B road. Stay on 229B road for 2.4 km and then stay right on unmarked road. Travel 0.3 km and stay left. Travel 1 km and stay left. Travel another 0.2 km to the end of the route (24 km).

Route 9.

Begin at Highway 87 and 142 road. West on 142 road to 142F road. North on 142F road 3.2 km and back to 142 road. West on 142 road to 142E road. North on 142E road for 3.2 km, then back to 142 road. Continue west on 142 road to 142B road. North on 142B road to 9365F road. North on 9365F road 1.3 km, left on fork that circles 0.8 km back to 9365F. Back to 142 road, then travel west to end of route (24 km).



permutation procedure probabilities that sites differed from random plots on the Chevelon and Mormon Lake study areas during summer, 1995-97. Means Appendix 3. Mean and standard deviation (SD) of tree variables measured at random plots and feeding, roosting, and loafing sites and multi-response that differ from random are displayed in bold italic type.

	Random plots	n plots	Fe	Feeding sites	8	R	Roosting sites	S		Loafing sites	
Parameter	ı×	SD	ı×	SD	Ь	iX	SD	Ь	i×	SD	Ь
Mean ponderosa pine DBH (cm)	20.9	11.3	21.9	23.0	0.740	28.1	14.4	0.007	15.4	7.8	0.046
Ponderosa pine basal area (m²/ha)	12.5	10.0	13.0	12.5	0.678	16.9	6.6	0.022	10.4	8.6	0.628
Ponderosa pine trees per ha	507.1	845.3	368.1	358.6	0.448	687.2	1678.4	0.694	447.5	424.3	0.744
Mean Gambel oak DBH (cm)	6.4ª	9.0	6.3	12.5	0.093	10.5	10.5	0.005	8.3	10.8	0.772
Gambel oak basal area (m²/ha)	1.7 ^b	3.4	2.4	6.3	0.278	2.9	2.5	<0.001	1.7	2.8	0.999
Gambel oak trees per ha	148.8°	333.8	59.2	126.7	0.040	406.9	493.2	<0.001	129.0	184.0	0.799
Gambel oak seedlings per ha	57.1 ^d	142.6	25.8	48.7	0.083	96.3	117.7	0.000	53.8	55.8	0.267
Mean juniper DRC (cm)	22.6	18.0	24.8	26.2	0.244	17.5	14.4	0.265	20.6	19.3	0.999
Juniper basal area (m²/ha)	2.6 ^e	5.3	5.1	18.2	0.449	1.5	3.2	0.307	3.1	7.9	0.999
Juniper trees per ha	63.1	117.4	83.4	225.5	0.410	46.1	64.8	0.414	50.8	70.1	0.519
Conifer seedlings per ha	474.6 ^f	754.3	536.8	854.4	0.450	239.7	315.3	0.018	278.7	187.8	0.122
Total basal area (m²/ha)	16.78	11.8	20.5	28.9	0.499	21.2	6.6	0.028	15.1	12.1	0.841
Shrubs per ha	3,281.8 ^h	6,057.3	4,906.0	9,915.1	0.395	7,215.3	14,578.9	0.090	3,569.2	7,366.0	0.770

⁴Differs between study areas, Chevelon study area (CSA) = 3.7 (7.9), Mormon Lake study area (MLSA) = 9.5 (9.2), MRPP P < 0.001. ^bDiffers between study areas, CSA = 0.7 (1.9), MLSA = 2.8 (4.3), MRPP P < 0.001

Expression of the control of the co

^dDiffers between study areas, CSA = 8.1 (49.7), MLSA = 101.3 (193.3), MRPP P < 0.001.

^{*}Differs between study areas, CSA = 1.4 (3.0), MLSA = 3.9 (6.9), MRPP P = 0.022.

¹Differs between study areas, CSA = 560.1 (609.9), MLSA = 377.8 (887.6), MRPP P = 0.008. SDiffers between study areas, CSA = 14.1 (10.9), MLSA = 19.8 (12.1), MRPP P = 0.020.

^{&#}x27;Differs between study areas, CSA = 3914.8 (4965.0), MLSA = 2564.3 (7086.3), MRPP P < 0.001.

sites differed from random plots on the Chevelon and Mormon Lake study areas during summer, 1995-97. Means that differ from random are displayed Appendix 4. Mean and standard deviation (SD) of percent canopy cover from line-intercept transects by height category (class 1:0-45.9 cm, class 2:46-91.9 cm, and class 3:92-184 cm) at random plots and feeding, roosting, and loafing sites, and multi-response permutation procedure probabilities that in bold italic type.

	Randor	Random plots	Fe	Feeding sites	S	RG	Roosting sites	ŞŞ	L(Loafing sites	
Parameter	ı×	SD	ıx	SD	P	ı×	SD	Ь	ı×	SD	Р
Class 1 forb	2.3	2.6	3.8	5.3	0.091	1.7	2.0	0.207	1.6	2.3	0.315
Class I grass	6.7	0.6	8.3	10.9	0.540	4.1	4.1	0.131	4.0	5.8	0.098
Class 1 downed wood	7.7 ^a	11.1	8.9	4.7	0.720	6.3	5.5	0.167	12.1	9.3	0.012
Class 2 downed wood	0.3	6.0	0.1	0.4	0.154	0.4	1.2	0.999	6.0	1.9	0.143
Class 1 conifer tree	8.0	1.6	6.0	1.4	0.520	2.0	1.7	<0.001	1.7	3.0	0.301
Class 2 conifer tree	1.3	2.4	1.1	1.6	0.355	2.4	2.9	0.003	2.7	4.5	0.158
Class 3 conifer tree	3.7	7.8	2.9	5.0	0.750	3.6	3.2	0.052	6.5	7.2	0.030
Class 1 deciduous tree	1.3 ^b	3.9	9.0	1.6	0.234	1.7	2.9	0.064	8.0	1.3	0.304
Class 2 deciduous tree	0.8°	2.8	0.3	1.2	0.184	1.5	2.8	0.056	0.1	0.3	0.145
Class 3 deciduous tree	_p 9.0	2.5	0.4	1.3	0.803	1.2	1.9	0.006	8.0	1.7	0.456
Class 1 shrub	0.9 ^e	2.8	1.2	2.9	0.392	6.0	2.6	0.803	0.3	0.7	0.304
Class 1 rock	11.6	12.7	5.6	5.7	0.002	12.3	8.9	0.205	7.5	8.6	0.207
Class 1 total cover	31.2	18.9	27.3	13.8	0.433	28.9	12.6	0.562	28.0	11.2	0.334
Class 2 total cover	4.0	7.5	2.3	2.8	0.073	5.1	4.5	0.000	3.7	4.8	0.437
Class 3 total cover	5.3	7.6	3.7	5.7	0.451	5.0	3.6	0.012	7.7	7.3	0.044

*Differs between study areas, Chevelon study area (CSA) = 9.8 (14.), Mormon Lake study area (MLSA) = 5.3 (4.5), MRPP P = 0.002. ^aDiffers between study areas, CSA = 0.6 (3.1), MLSA = 2.1 (4.5), MRPP P < 0.001.

Differs between study areas, CSA = 0.0 (5.1), MLSA = 2.1 (4.2), MRPP P < 0.001. Chiffers between study areas, CSA = 0.2 (0.8), MLSA = 1.5 (3.), MRPP P < 0.001.

^dDiffers between study areas, CSA = 0.1 (0.4), MLSA = 1.1 (3.6), MRPP P = 0.030.

Differs between study areas, CSA = 0.4 (0.7), MLSA = 1.4 (4.0), MRPP P < 0.001.

permutation procedure probabilities that sites differ from random plots on the Chevelon and Mormon Lake study areas during the summer, 1995-97. Means Appendix 5. Mean and standard deviation (SD) of site variables measured at random plots and feeding, roosting, and loafing sites, and multi-response that differ from random are displayed in bold italic type.

	Random plots	n plots	Fe	Feeding sites		, K	Roosting sites	y.		Loafing sites	y.
Darameter											
ı alalılıcıcı	IX	SD	i×	SD	Ь	ΙX	SD	Ь	ΙX	SD	Ъ
Slope (%)	16.2	13.4	12.7	9.1	0.162	33.6	12.9	<0.001	23.3	14.3	0.018
Turkey HSD (m)	37.4	17.3	42.3	20.0	0.292	33.7	16.5	0.158	26.6	8.5	0.004
Person HSD (m)	57.1	25.9	67.4	51.5	0.390	48.5	34.3	0.016	81.1	134.6	0.546
Canopy completeness (%)	43.5 ^a	23.8	40.4	22.8	0.392	64.1	15.5	<0.001	55.7	23.9	0.093
Height to first canopy (m)	8.2 ^b	8.0	7.2	6.2	0.538	12.7	7.3	0.003	4.6	3.7	0.101
Herbaceous height at site (cm)	7.7c	5.6	7.8	5.8	0.679	8.5	5.4	0.143	3.7	2.2	<0.001
Herbaceous height in opening (cm)	10.7	7.1	10.8	8.0	0.905	13.3	8.7	0.088	8.8	4.6	0.293
Distance to opening (m)	3.0	6.7	3.0	4.5	0.165	4.5	4.3	0.001	8.4	9.5	0.001
Opening size (m^2)	1,647.4 ^d	1,938.3	1,573.7	1,603.9	0.939	1,047.1	1,267.0	0.121	1,282.8	1,140.4	0.416
Distance to cover (m)	24.9	16.8	26.6	26.5	0.635	19.5	13.6	0.238	19.8	14.2	0.421

^aDiffers between study areas, Chevelon study area (CSA) = 37.1 (22.0), Mormon Lake study area (MLSA) = 50.8 (23.8), MRPP P = 0.007. ^bDiffers between study areas, CSA = 5.5 (4.2), MLSA = 11.6 (10.3), MRPP P = 0.017.

Differs between study areas, CSA = 7.1 (5.7), MLSA = 8.4 (5.5), MRPP P = 0.046.

Differs between study areas, CSA = 1938.2 (1849.0), MLSA = 1329.4 (2004.6), MRPP P = 0.039

Appendix 6. Chi-square, degrees of freedom, and probabilities that use sites differ from random plots for categorical site variables measured at feeding, roosting, and loafing sites on the Chevelon and Mormon Lake study areas during the summer, 1995-97. Those that differ from random are displayed in bold italic type.

	_ Fee	ding :	sites	Roo	sting	sites	Loat	ing s	ites
Categorical variable	χ^2	df	P	χ^2	df	P	χ^2	df	P
Silvicultural treatment history	4.681	2	0.096	1.910	2	0.385	0.139	2	0.933
Understory distribution	0.001	1	0.999	0.004	1	0.948	0.411	1	0.522
Overstory distribution	0.286	1	0.593	1.030	1	0.310	0.078	1.	0.780
Canopy structure	3.039	2	0.219	5.970	2	0.050	0.361	2	0.835
Aspect	6.908	3	0.075	4.450	3	0.217	2.146	3	0.543
Land form	5.893	4	0.207	17.021	4	0.002	4.857	4	0.302
Position on slope	1.400	2	0.497	6.724	2	0.035	3.772	2	0.152
Overhead canopy presence at site center	1.133	1	0.287	17.739	1	<0.001	10.010	1	0.002
Presence of canopy opening within 200 m	1.532	1	0.216	0.752	1	0.386	0.578	1	0.447
Presence of barren campsite core	4.195	1	0.057	0.001	1	0.999	0.001	1	0.999
Presence of human-induced	6.499	1	0.011	16.147	1	<0.001	3.436	1	0.064
Presence of trash	3.246	1	0.072	0.567	1	0.451	0.382	1	0.537
Presence of camp fire rings	3.214	1	0.073	0.315	1	0.575	0.189	1	0.664

Appendix 7. Corrected mean diet composition of male Merriam's turkeys on the Chevelon and Mormon Lake study areas, Arizona, during summer (May 15-September 15) 1996 and 1997.

	Chevelon	study area	Mormon Lak	ce study area
Dietary item	1996	1997	1996	1997
Agropryron smithii	0.3	0.6	0.6	1.6
Aristida spp	0.0	0.1	0.0	0.0
Bromus ciliatus	4.4	0.2	1.5	8.9
Carex spp.	0.6	0.8	2.6	0.7
Dactylis glomerata	0.7	0.0	1.9	0.0
Festuca arizonica	0.0	1.9	0.2	3.4
Poa spp.	0.0	0.8	0.9	1.4
Stipa comata	0.2	1.1	0.0	0.5
Other grasses	0.4	1.5	1.7	2.2
Total grasses	6.6	7.0	9.4	18.7
Forb 1ª	30.8	62.4	14.7	35.6
Forb 2 ^b	27.4	4.7	31.5	13.1
Forb 3°	0.0	11.1	2.8	0.7
Trifolium spp.	8.0	7.3	5.3	0.0
Composite	8.0	1.6	3.5	1.1
Other forbs	9.4	4.0	19.6	17.5
Total forbs	83.6	91.1	77.3	68.0
Total shrubs	0.0	0.0	0.0	0,2
Juniper berry	3.2	1.6	9.2	8.2
Juniper needle	0.0	0.0	0.1	0.1
Ponderosa pine seed	1.1	0.0	0.0	0.6
Ponderosa pine needle	0.1	0.0	0.0	0.0
Gambel oak acorn	2.4	0.2	0.0	2.4
Total trees	6.8	1.8	9.3	11.3
Insect	3.0	0.4	4.2	2.2

^aForb 1 possibilities are Agoseris, Erysimum, or Lithospermum.

^bForb 2 possibilities are *Lithophragma* or *Saxifraga*.

 $^{^{\}mathrm{c}}$ Forb 3 possibility is Tragapogon.

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